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PIER Strategic Program-Strategic Distributed Energy Resources Research Assessment

Interim Report

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Submitted to:

California Energy Commission
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Table of Contents

List of Figures

Preface

This report presents Arthur D. Little's interim findings and observations related to Distributed Energy Resources (DER) for the California Energy Commission Public Interest Energy Research (PIER) Strategic Program. The high level observations outlined in this report will be presented at a public workshop on August 28, 2001 at the California Energy Commission. The primary objective of this workshop is to identify gaps in the research programs already initiated by government organizations and private industry. Workshop participants will 1) clarify and add research focus areas and 2) contribute to the potential priorities for the Strategic Program's research plan and upcoming solicitation. This workshop will *not* address the project level details presented in this report. Comments or questions on any aspect of this report including both the high level observations and the project details should be addressed to:

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Executive Summary

The CEC Public Interest Energy Research (PIER) Strategic Program is developing its 5-year research plan in the area of DER relating to:

- interconnection
- grid impacts
- market integration

A preliminary literature search of multiple sources was first conducted to determine past, present and planned research in the private and public sectors. Significant additional input was obtained through an interview process with representatives of industry, non-profit and government efforts in DER. Key issues and strategies to address them in the three areas of interconnection, grid impacts and market integration were identified and organized.

Under the interconnection area, there are 15 strategies that make up three strategic thrusts that could allow for a substantial amount of DER to be interconnected in radial and networked systems:

- *Standardization and adoption of new requirements and processes*
- *Cost reduction and product improvement*
- *Compatibility*

Under the grid impacts area, there are 11 strategies that make up four major thrusts that could lead to an understanding of what impact a high penetration of DER would have on the electric power system:

- *Modeling and testing*
- *System impact studies*
- *Microgrids*
- *Wires company information needs*

Under the market integration area, there are 12 major strategies that make up three strategic thrusts that may provide DER with access to robust markets and/or exposure to price signals that will maximize the benefits of DER to customers and the power system:

- *Current market*
- *Advanced market concepts*
- *Enabling technologies*

The projects, activities and strategies were mapped against the state of the technology development and the pathway of competitive impact. The four states of technology development are research, development, demonstration and commercialization. Competitive impact follows a pathway of four levels, defined as follows:

Base: Although essential to the business, these technologies cannot provide significant competitive advantage

Key: These technologies are critical for today's bases of competition

Pacing: Although they are not fully embodied in current products, they may, if successfully applied, have a substantial impact on the basis of competition in the reasonably near future

Emerging: These technologies may have an impact on competition in the future but this is far from certain

Additionally, the degree to which the strategies had been pursued was captured such that each of the strategies is identified as either having significant, moderate or little/no gap. A more significant gap implies greater need for investment or activity.

From the analysis completed thus far, the following preliminary observations were drawn:

- The economic feasibility of many DER applications has yet to be demonstrated to a satisfactory degree on a wide-scale basis.

- The infrastructure to allow DER to participate in the marketplace and maximize its benefits to customers and the electric power system is still far from developed, thereby limiting the potential economic upside for end users.

- There are as many opportunities on the regulatory and policy side as there are on the technology development side. Indeed, in many instances, policy development has not kept pace with the development of technology.

- Stakeholders at all levels need to be engaged and educated to allow for follow-through to take place unhindered once the groundwork technology or policies are in place.

- Technology and policy development has already taken place over the past several years funded and supported by government and collaborative organizations. In recent years, commercial interest in this area has increased dramatically.

- Some significant opportunities still exist for high-impact projects in all three of the topic areas: interconnection, grid impacts and market integration.

Chapter 1: Introduction

Significant developments in Distributed Energy Resources (DER) technology and the marketplace require a fresh analysis of the DER landscape to identify key challenges appropriate for public interest research. The CEC Public Interest Energy Research (PIER) program Strategic Area is developing its 5-year research plan in the area of DER relating to:

- interconnection,
- grid impacts
- market integration

Given PIER Strategic Area's task to focus on systems level and cross-cutting areas of technology development, it would be inappropriate to for the Strategic Area to focus on, for example, renewable energy or environmentally preferred generation options in a more isolated context. Thus, interconnection, grid impacts, and market integration were specifically targeted by the Strategic Area despite the wide range of technologies associated with DER.

A major step in the research plan development process is to understand current research being conducted by industry, nonprofit organizations and government; and to identify where gaps exist. Information collected through research, interviews, and a public workshop will help identify appropriate PIER program activities. From these efforts, the CEC PIER Strategic Area will develop a solicitation to address those activities.

Background Research and Interviews

This research effort began with a preliminary literature search of multiple sources to determine past, present and planned research in the private and public sectors. Results of the literature search served as a preliminary roadmap to identifying major topics of research as well as potential interview candidates for sources of additional information on DER research activities.

Significant input was obtained through an interview process with representatives of industry, non-profit and government efforts in DER. Conversations and completed questionnaires captured concerns, additional information and insight into the nature of research efforts. Together along with the information gathered in the literature search, the interview data was used to formulate the key issues and strategies facing DER in the areas of interconnection, transmission and distribution system impacts, and market integration.

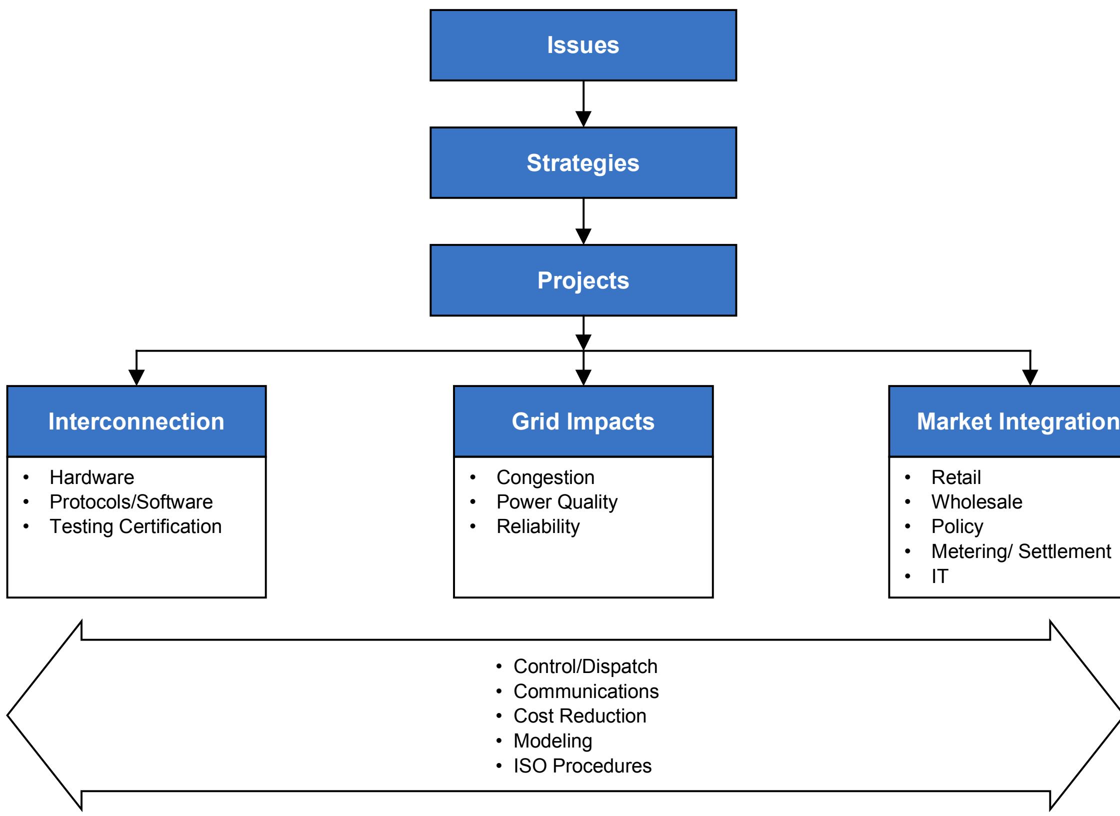
The organizations found to be active in DER technology development can be found in the Appendix. More than half of these organizations was contacted through the course of this work.

Framework of Analysis

In parallel with and incorporating the information gathered from the background research and interviews, a framework was created for assessing the status of the DER research efforts (Figure 1-1)

Issues are the critical questions facing the development of DER in the areas of interest. These issues have driven, or will drive, the creation of **Strategies** to address these questions. Current and potential **Projects,** in each of the three areas, are employing these strategies. There are also crosscutting projects that are addressing issues in more than one area. Each project/activity identified can be mapped to the appropriate strategy and issue. Chapter 2 delves deeper into the details surrounding the process by which the issues were identified and elaborates on the strategies that address those issues.

Figure 1-1: Taxonomy of Analysis Framework



Representative research projects most applicable to the research objectives of the CEC Strategic Area are detailed in Chapter 3. Equipped with the issues, strategies, and project information, the level and concentration of activities are mapped out and potential areas where funding might be warranted are thus revealed in Chapter 4. Inclusion of the elements stated thus far opens the way for a more effective discussion among the various stakeholders in DER development. Preliminary observations are detailed in Chapter 5.

Public Workshop and Final Report

The August 28, 2001 public workshop will be a forum to discuss the findings of this interim DER Research Assessment Report. The purpose of this workshop is to get direct feedback from industry, government, academia and others about the issues facing DER systems in the subject areas of interest to the Strategic Program.

Additional information and insights obtained during the workshop will be incorporated in the final report that will be made available in late September 2001.

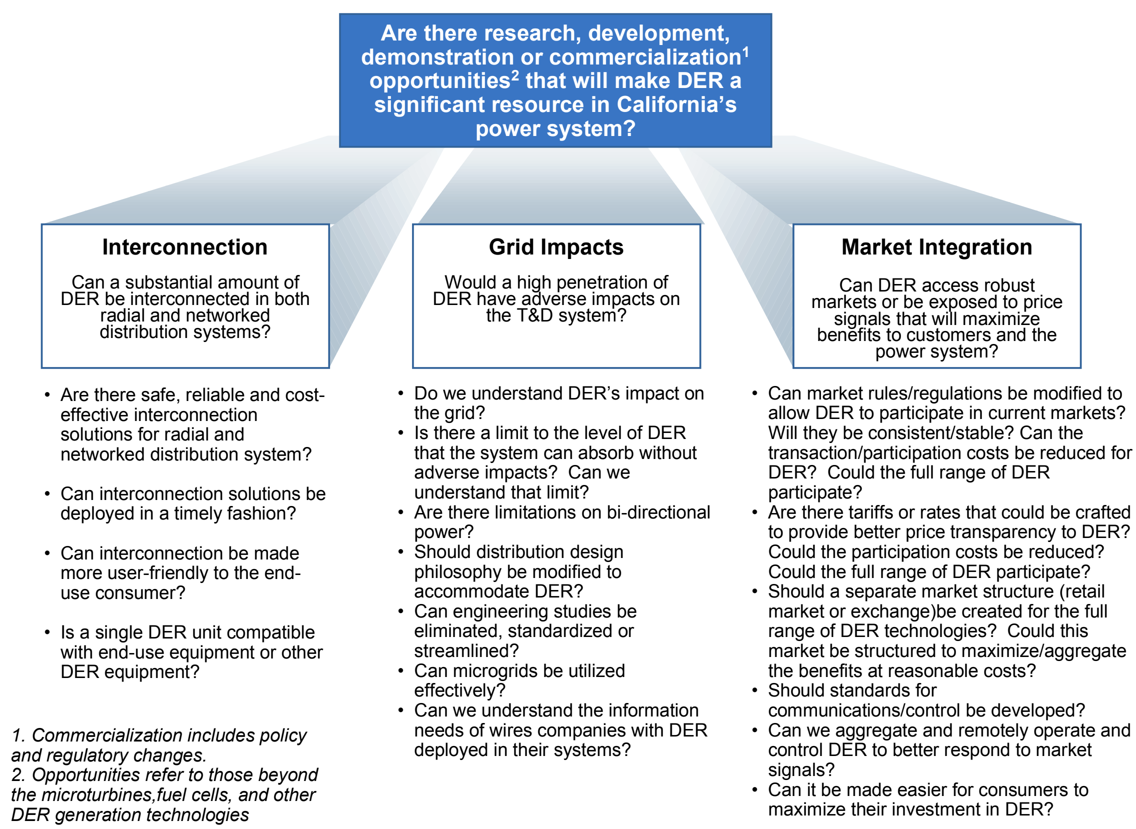
Chapter 2: Issues and Strategies

The results of the literature search and the interviews provided essential inputs to isolate issues facing Distributed Energy Resources and the strategies to address these issues. In the interviews, representatives of industry, non-profit organizations and government provided information on their visions for DER, where key obstacles exist, where their DER efforts are focused, and the expected outcome for such efforts.

Issues

The Arthur D. Little staff and experts involved in the literature search and interviewing process came together as the interview process drew to a close. The information that had been collected was pooled and carefully examined for key insights. Obstacles to more effective adoption of distributed energy resources discovered during the information collection process were organized. While it is not in CEC PIER's domain to engage in activities involving the commercialization of technologies, commercial impacts need to be included in the analysis for the sake of completeness. The issues identified in the form of critical questions and arranged along the lines of the three topic areas: interconnection, grid impacts and market integration (Figure 2-1).

Figure 2-1: DER Issues Analysis



Strategies

Current and proposed paths to overcoming the issues were identified during the interview process and formed the basis of the strategies identified. The strategies address the issues in the three topic areas of interconnection, grid impacts and market integration.

Interconnection

There are 15 strategies that make up three strategic thrusts (Figure 2-2) that could allow for a substantial amount of DER to be interconnected in radial and networked systems:

- *Standardization and adoption of new requirements and processes*
- *Cost reduction and product improvement*
- *Compatibility.*

Specific comments regarding interconnection issues and strategies received during the interview process are provided below.

Figure 2-2: Interconnection Issues and Strategies

Interconnection

Can a substantial amount of DER be interconnected in both radial and networked distribution systems?

Issues	Strategies	
Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? Can interconnection solutions de deployed in a timely fashion? Can interconnection be made more user-friendly to the end-use consumer?	**Standardization and Adoption of New Requirements and Processes** • Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Understand impact of and adopt new interconnection requirement • Standardize designs around new requirements • Type testing and certification of interconnection solutions • Develop guidelines and best practices for interconnection • Modify standardized requirements and standardized designs based on modeling, testing and field experience • Educate stakeholders on new requirements, contracts and processes • Develop standardized products for small DER	**Cost Reduction and Product Improvement** • Reduce costs of interconnection components • Improve reliability and performance of interconnection components (e.g., power electronics) • Integrate interconnection functions with other DER functions • Turnkey solutions that integrate DER functions • Develop new technologies that would eliminate or reduce some requirements or costs of interconnection
Is a single DER unit compatible with end-use equipment or other DER equipment?	**Compatibility** • Develop test protocols for compatibility and power quality testing of DER • Test and understand compatibility and power quality issues	

"The largest DER impediments are…the lack of a consensus *national* utility interconnection document…"

-A non-profit organization

"With Rule 21, interconnection is no longer an issue." [in California]

-Electricity distribution company

"We need to start looking beyond 1547, there is more to it than just writing a standard. We need to understand the impact of the standard, educate stakeholders and develop guidelines."

- Research institute

"A nightmare for us is a different standard from state to state or utility to utility."

- An interconnection component manufacturer

"The [interconnection] solutions have got to be more customer-focused…easier, faster, cheaper or we won't even get a chance to be considered."

- DR technology developer

Grid Impacts

There are 11 strategies that make up four major thrusts (Figure 2-3) that could lead to an understanding of what impact a high penetration of DER would have on the electric power system:

- *Modeling and testing*
- *System impact studies*
- *Microgrids*
- *Wires company information needs*

Specific comments regarding interconnection issues and strategies received during the interview process are provided below.

Figure 2-3: Grid Impacts Issues and Strategies

Grid Impacts

Would a high penetration of DER have adverse impacts on the T&D system?

Issues	Strategies
Do we understand DER's impact on the grid? Is there a limit to the level of DER that the system can absorb without adverse impacts? Can we understand that limit? Are there limitations on bi-directional power? Should distribution design philosophy be modified to accommodate DER?	**Modeling and Testing** • Model and analyze the grid with varying levels of DER penetration • Demonstrate and test varying levels of DER penetration in a distribution systems • Modify distribution system design approaches
Can engineering studies be eliminated, standardized or streamlined?	**System Impact Studies** • Develop models to understand system impacts • Develop software to facilitate impact studies • Modify requirements for impact studies as appropriate
Can microgrids be utilized effectively?	**Microgrids** • Model and analyze microgrids • Demonstrate and test microgrids • Develop design guidelines for microgrids
Can we understand the information needs of wires companies with DER deployed in their systems?	**Wires Company Information Needs** • Perform analysis of the information and data needs of wires companies • Develop and demonstrate systems for wires companies to monitor DER

"Clarity on interconnection allowing people to sell power back to the grid will bring investors in DER further benefits. Market power vested interests are another major obstacle. Technically, there are some concerns that a lot of power flowing back and forth can be unsafe…which may be a smoke screen for the market vested interests."

-An interconnection package manufacturer

"There is no solid proof of reliability given the lack of protection coordination devices allowing for bi-directional flow of electricity."

-A diversified equipment manufacturer

"What exactly is the level of penetration of DG before it will have a negative impact? Right now we are just using thumb rules. Will we need to change our requirements when the penetration goes up?"

-Utility distribution engineer

"Microgrids and power parks could provide significant benefits and should not be overlooked."

-University researcher

"We need to understand the dynamic interaction between DER units within microgrids...we need to develop control and protection schemes and dispatch algorithms."

-National laboratory researcher

"Much of the DR commercial development has been working around the wires companies. I think this is a mistake. Wires companies need to be involved to maximize the benefits. The first step is having a system that will let the wires companies know where the DR is currently installed in their systems…eventually they will see the benefits to their systems."

-Nonprofit research organization

Market Integration

There are 12 major strategies that make up three strategic thrusts (Figure 2-4) that may provide DER with access to robust markets and/or exposure to price signals that will maximize the benefits of DER to customers and the power system:

- *Current market*
- *Advanced market concepts*
- *Enabling technologies*

Specific comments regarding market integration issues and strategies received during the interview process are provided below.

Figure 2-4: Market Integration Issues and Strategies

Market Integration

Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

<table>
<tr><th colspan="2">Issues</th><th colspan="2">Strategies</th></tr>
<tr>
<td rowspan="3">Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?

Can it be made easier for consumers to maximize their investment in DER?

Should standards for communications/control be developed?</td>
<td>Can market rules/regulations be modified to allow DER to participate in current wholesale markets? Will they be consistent/stable? Can the transaction/ participation costs be reduced for DER? Could the full range of DER participate?</td>
<td rowspan="2">Current Market
• Assess current wholesale market rules for applicability to DER
• Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
• Reduce costs by creating critical mass through a demonstration program
• Integrate the required technologies to reduce costs of participating in markets
• Assess requirements for tariffs or rates</td>
<td rowspan="3">Enabling Technologies
• Demonstrate aggregation and control of DER
• Develop low cost metering
• Develop low cost communications and control
• Develop software to optimize DER in response to market price signals
• Develop standards/protocols for communications/control</td>
</tr>
<tr>
<td>Are there tariffs or rates that could be crafted to provide better retail price transparency to DER? Could the participation costs be reduced? Could the full range of DER participate?</td>
</tr>
<tr>
<td>Should a separate market structure (retail market or exchange)be created for the full range of DER technologies?

Could this market be structured to maximize/aggregate the benefits at reasonable costs?</td>
<td>Advanced Market Concepts
• Launch a new market for DER
a Start from scratch, develop the best market structure for DER now and in the future
b Assess the system requirements for communications, control, metering, software for billing and settlement
c Pilot and then launch
• Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)</td>
</tr>
</table>

"ISO Tariff changes and participation requirements may be necessary before DER can participate in the ISO Markets and function as part of the ISO's Control Area resources, even if the technologies are fully developed."

-A regulatory body

"The technology to maximize the benefits of DER is there, however it does need to be integrated and that is not trivial… and of course tariffs and market rules would have to change."

-Software developer

"The biggest obstacles are the uncertainty of what you can and cannot do…we need consistency, clarity and stability."

-DR technology developer

"Scheduling fees, metering, applications fees, wholesale distribution tariffs…I can't see how small DER projects could economically participate with the ISO market."

-Electricity distribution company

"We need to develop scale in the market place to reduce costs…subsidizing infrastructure or acting as a catalyst to bring this together would be a good role for the CEC."

-DR technology developer

"Inexpensive, broadly deployed monitoring, control and communications systems are key. Wireline communications for 10-12 DG units works fine…but when you are talking about 100s or 1000s of units this approach is limited…you are going to have to look for alternative approaches…understand the costs and what data is actually needed and when."

-DG communications developer

"Start educating architects and engineers on DG: technology and economic aspects…There need to be analytical tools to quantify the benefits to the utility."

-A nonprofit organization

Chapter 3: Current R&D Projects

Many companies and organizations were found to be conducting distributed energy research and technology development regarding interconnection, grid impacts, and market integration. To determine the focus of current research, the issues and strategies being addressed by each project or project category were determined. To gain further insight into the nature of this research and technology development, the projects were also analyzed by their stage of technology development and their competitive impact.

All technology follows a natural progression along the technology development chain; which consists of 4 stages: research, development, demonstration, and commercialization (Figure 3-1). At any given time, a technology's place on this chain is fixed regardless of the industry to which the technology is applied. Therefore, a technology's place on the development chain is intrinsic to the technology.

Figure 3-1: Technology Development Process

Research	Development	Demonstration			Commercialization	
		Initial System Prototypes	Refined Prototypes	Commercial Prototypes	Market Entry	Market Penetration
• General assessment of market needs • Assess general magnitude of economics • Concept and Bench testing • Basic research and sciences (e.g., materials science)	• Research on component technologies • Development and initial of product offering • Pilot testing	• Integrate component technologies • Initial system prototype for debugging • Demonstrate basic functionality	• Ongoing development to reduce costs or for other needed improvements • "Technology" (systems) demonstrations • Some small-scale "commercial" demonstrations	• "Commercial" demonstration • Full size system in "commercial" operating environment • Communicate program results to early adopters/ selected niches	• Initial commercial orders • Early movers or niche segments • Product reputation is initially established • Business concept implemented • Market support usually needed to address high cost production	• Follow-up orders based on need and product reputation • Broad(er) market penetration • Infrastructure developed • Full-scale manufacturing

Competitive impact describes how important a technology is to the way companies compete. As such, it always refers to a given product or industry. Competitive impact, therefore, is extrinsic and closely related to the industry in which the technology is applied. Competitive impact follows a pathway of four levels (Figure 3-2), defined as follows:

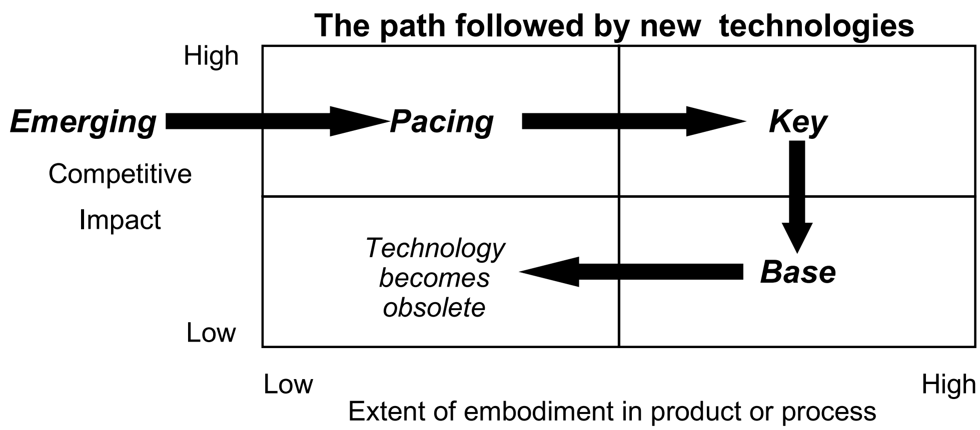
- BASE: Although essential to the business, these technologies cannot provide significant competitive advantage

- KEY: These technologies are critical for today's bases of competition

- PACING: Although they are not fully embodied in current products, they may, if successfully applied, have a substantial impact on the basis of competition in the reasonably near future

- EMERGING: These technologies may have an impact on competition in the future but this is far from certain

Figure 3-2: Technology Pathway



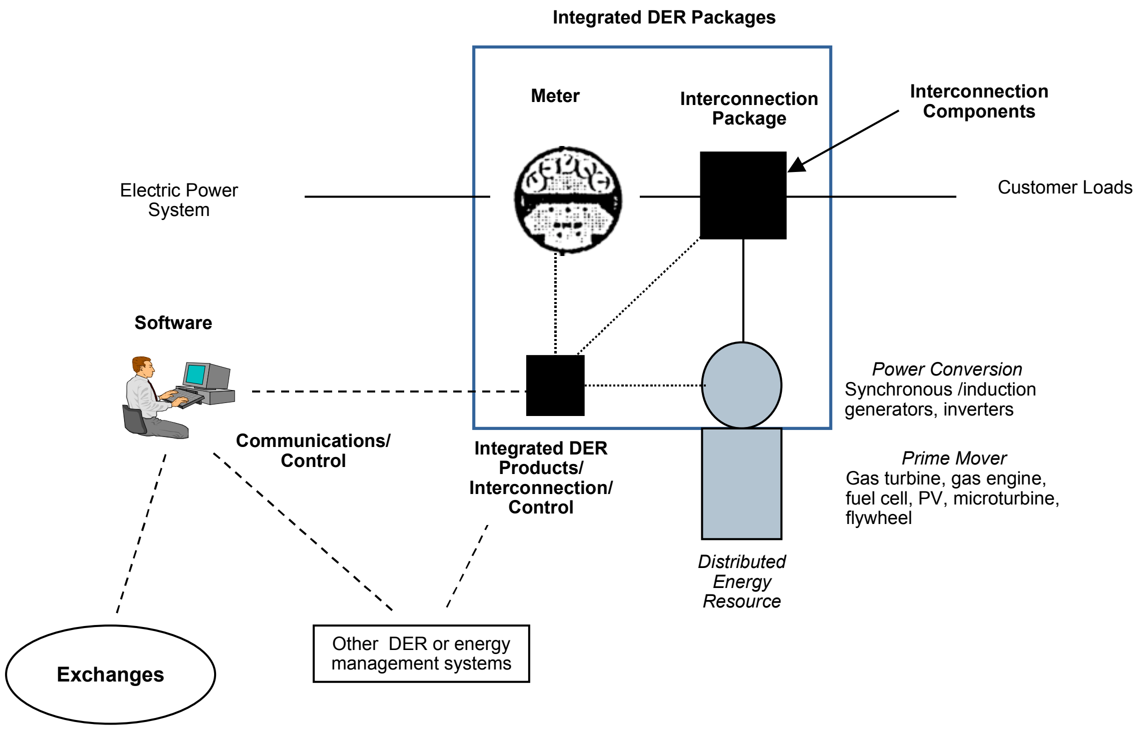
Examining the intrinsic (technology development stage) and extrinsic (competitive impact) of a technology provides a useful format to determining which technologies should be pursued, the appropriate level of investment and the timing for that investment. Technical risk varies along the technology development chain; the highest risk associated with research. Market risk varies along the level of competitive impact; the highest risk is with emerging technologies. Reward does not vary by where the technology is on the technology development chain; however, emerging technologies offer higher reward than base technologies. Therefor, research in emerging technologies has the highest technical/market risk and the highest reward; commercial, base technologies have the lowest market/technical risk and the lowest. For emerging commercial technologies, there is little technical risk, but high market risk and high rewards.

Both private sector and publicly funded technology development efforts were profiled and basic information collected. The issues and strategies each technology or project is pursuing were identified; and its technology development stage and competitive impact were assessed.

Private Sector

Private sector technology development was further organized into seven general categories (Figure 3-3) to facilitate the strategic analysis:

Figure 3-3: Private Sector Technologies Categories



1. *Interconnection Components* – Provides functionality (e.g. protection and parallel operation) of the interconnection package. Includes transfer switches, breakers, relays, and inverters

2. *Interconnection Package* – Provides safe and reliable parallel operation and isolation between DER units and the electric power system, and protection for the electric power system

3. *Integrated DER Products/Interconnection/Control* – Provides a turnkey solution at lower costs by integrating the interconnection components, controls, power conversion, communication, and/or metering into a single package.

4. *Communications/Control* – Provides remote monitoring, control and aggregation of DER. The communication might be two-way and include control signals to respond to price signals, perform diagnostics or provide information and status reports. Communication could be with other DER devices, ISOs, central control or a building energy management system. Communication technology options include SCADA, telephone lines, LAN, internet, paging and cellular.

5. *Software* – Optimizes DER, performs economic dispatch, provides billing and settlement and aggregation. Uses information and real-time or near real-time data from the DER, the marketplace, customer energy management system, ISO, and or other DER units.

6. *Advanced Metering* – Provides information and data to optimize DER, verification, billing and settlement.

7. *Exchanges* – Provides a site where DER owners can sell their output, demand reduction, transmission congestion benefits or other benefits to ISOs, utilities, wires companies, power marketers, energy retailers or other customers.

Products/technologies, issues, strategies, and a sample of the companies involved were determined for each of the above areas (Figures 3-4 through 3-10).

Figure 3-4: Interconnection Components (1)

Products/Technology	Issues	Strategy	
Interconnection Components (e.g., switchgear, inverters, relays)	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?	• Reduce costs and improve reliability of components • Improve performance of interconnection components (e.g., power electronics) • Integrate interconnection functions with other DER functions • Develop new technologies that would eliminate or reduce some requirements or costs of interconnection	
Illustrative Companies	ABB ASCO Eaton GE Zenith Controls Satcon Sustainable Energy Technologies Ltd Woodward Industrial Controls Xantrex	**Technology Characteristic**	**Key/Base**
		Technology Status	**Commercial**

Figure 3-5: Interconnection Package (2)

Products/Technology	Issues	Strategy	
Interconnection Package	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Can interconnection be made for user friendly to the consumers?	• Standardize designs around new requirements • Integrate interconnection functions with other DER functions • Develop turn-key solutions that integrate DER functions • Develop new technologies that would eliminate or reduce some requirements or costs of interconnection • Develop new standardized products for smaller DER	
Illustrative Companies	ASCO ENCORP Enercon Engineering GE Zenith Controls Thomson Technology	**Technology Characteristic**	**Base**
		Technology Status	**Commercial**

Figure 3-6: Integrated DER Products/Interconnection/Control (3)

Products/Technology	Issues	Strategy	
Integrated DER Products/Interconnection/ Control	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Can interconnection be made more user friendly to the consumers? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	• Standardize designs around new requirements • Integrate interconnection functions with other DER functions • Develop turn-key solutions that integrate DER functions • Integrate required technologies to reduce costs of participating in power markets • Develop low cost communications and control	
Illustrative Companies	Capstone Cummins Kohler	**Technology Characteristic**	**Key**
		Technology Status	**Demonstration/ Commercial**

Figure 3-7: Communications/Control (4)

Products/Technology	Issues	Strategy	
Communications/Control	• Should standards for communications/ control be developed? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)? • Can it be easier for consumers to maximize their investment in DER?	• Develop standards/protocols for communications/control • Develop low cost communications and control • Integrate the required technologies to reduce costs of participating in the power market	
Illustrative Companies	Electrotek Concepts ENCORP Omnimetrix Cannon Technologies Engage Networks	**Technology Characteristic**	**Pacing**
		Technology Status	**Demonstration**

Figure 3-8: Software (5)

<table>
<tr><th>Products/Technology</th><th>Issues</th><th colspan="2">Strategy</th></tr>
<tr><td>Software</td><td>Grid Impacts:
•Do we understand DER's impact on the grid?

•Is there a limit to the level of DER that the system can absorb without adverse impacts?

Market Integration:
•Can it be made easier for comsumers to maximize their investment in DER?

•Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?</td><td colspan="2">Grid Impacts:
Model and analyze the grid with varying levels of DER penetration

Market Integration:
Develop software to optimize DER in response to market price signals</td></tr>
<tr><td rowspan="2">Illustrative Companies</td><td rowspan="2">Market Integration:
Enermetrix, Power Technologies Inc, Powerweb Technologies, Retx, Silicon Energy, Sixth Dimension

Grid Impacts:
Siemens, Alstom, ABB</td><td>Technology Characteristic</td><td>Pacing</td></tr>
<tr><td>Technology Status</td><td>Demonstration</td></tr>
</table>

Figure 3-9: Advanced Metering (6)

<table>
<tr><th>Products/Technology</th><th>Issues</th><th colspan="2">Strategy</th></tr>
<tr><td>Advanced Metering</td><td>Can the transaction/participation cost be reduced for DER to participate in power markets?</td><td colspan="2">Develop low cost metering</td></tr>
<tr><td rowspan="2">Illustrative Companies</td><td rowspan="2">Itron
Power Measurement
Connectisys
Invensys
American Meters</td><td>Technology Characteristic</td><td>Key</td></tr>
<tr><td>Technology Status</td><td>Demonstration/ Commercial</td></tr>
</table>

Figure 3-10: Exchanges (7)

Products/Technology	Issues	Strategy	
Exchanges	• Should a separate market structure be created for the full range of DER technologies? Could this market be structured to maximize/aggregate the benefits at reasonable costs? • Can the transaction/participation cost be reduced for DER to participate in power markets?	• Reduce participation costs • Launch a new market for DER	
Illustrative Companies	Apogee	**Technology Characteristic**	**Pacing/Emerging**
		Technology Status	**Commercial**

Public/Collaborative/Non-Profit

There were 40 public/collaborative or non-profit projects identified (Figures 3-11 through 3-50):

1. CERTS DOE
2. CERTS CEC
3. MIT Energy Laboratory, Competitive Power Systems Group
4. University of Wisconsin, Pricing Models
5. University of Wisconsin, Location of DG
6. University of Wisconsin, Inverter Technologies
7. University of Wisconsin, Inverter Control Technologies
8. GTI - Integrated Switchgear and Interconnection Systems
9. GTI - Distributed Energy Technology Development Center
10. GTI - Remote Monitoring
11. IEEE/P1547 Electric Power Resources Interconnected with the Power System
12. GE Corporate R&D: DG/Utility System Interconnect
13. DTE - Aggregation Model and Field Testing
14. Distributed Utility Integration Test
15. NiSource - Advanced CHP Systems
16. Electrotek and NYSERDA - Aggregated DG
17. NRECA – Fuel Cells Performance
18. NRECA – Microturbines Performance
19. Industrial DG, Varying Load
20. GTI & ENCORP - Innovative Interconnection
21. Kelso Starrs and Associates - Interconnection Barriers
22. Regulatory Assistance Project
23. Urban Consortium Energy Task Force
24. UL 1741
25. Rule 21
26. UC, Irvine - Unified Control Inverter
27. UC, Irvine - Microgrids
28. UC, Irvine - Interconnection Design
29. UC, Irvine - SCAQMD Microturbine Demonstration
30. EPRI - IEEE P1547
31. EPRI - Completing the Circuit
32. EPRI - DER Engineering Guide and Workstation
33. EPRI - Development of DR Microgrids
34. EPRI - System Modeling for DR Impacts
35. EPRI - Interconnection Hardware
36. EPRI - DER Status and Condition Information System
37. Alternative Energy Systems Consulting - Smart*DER
38. DENNIS
39. Pleasanton Power Park
40. Sixth Dimension

Figure 3-11: CERTS DOE (1)

Project/Technology Development/Product	Issues	Strategy	Expected Results
One area of CERTS' research, comprised by 5 related projects, focuses on advancing the implementation of the microgrid concept. • Microgrid Outreach • Presentation to the Power System (requirements for grid integration of DER) • Protection Requirements • Microgrid Control • Study Tools (distribution system model, software)	Can microgrids be utilized effectively?	• Model and analyze microgrids • Demonstrate and test microgrids • Develop design guidelines for microgrids	Ultimately, the microgrid will be integrated into the power system and become another power source for the country.

Funding/Source	Participants	Point of Contact
DOE Transmission Reliability Program $750K (for FY01)	CERTS, which includes Pserc, Sandia National Laboratories, Pacific Northwest National Laboratories, Lawrence Berkeley Laboratory	Joseph Eto jheto@lbl.gov Lawrence Berkeley National Laboratory 1 Cyclotron Road, MS 90-4000 Berkeley, CA 94720 Tel: (510) 486-7284 Fax: (510) 486-6996

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Microgrids	Emerging	Research

Figure 3-12: CERTS CEC (2)

Project/Technology Development/Product	Issues	Strategy	Expected Results
CERTS is working on a long-term, multi-task project to capture the potential of DER and improve the reliability of the CA power system through new technologies and control strategies. Tasks include simulation of a microgrid, reduction of power electronics costs, customer adoption of DER, creating and utilizing test beds, and facilitating discussions on DER issues.	Can microgrids be utilized effectively?	• Model and analyze microgrids • Demonstrate and test microgrids • Develop design guidelines for microgrids	Microgrids will be integrated into the power system to improve reliability and power quality, lower power delivery costs, and reduce environmental impacts.

Funding/Source	Participants	Point of Contact
CEC PIER Strategic Program First year funding $500K	CERTS, which includes Pserc, Sandia National Laboratories, Pacific Northwest National Laboratories, Lawrence Berkeley Laboratory	Joseph Eto jheto@lbl.gov Lawrence Berkeley National Laboratory 1 Cyclotron Road, MS 90-4000 Berkeley, CA 94720 Tel: (510) 486-7284 Fax: (510) 486-6996

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts, *Market Integration, Interconnection*	Microgrids	Emerging	Research

Figure 3-13: MIT Energy Laboratory, Competitive Power Systems Group (3)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The competitive power systems group is developing models and software that will allow real-time transactions management, power flow control and pricing, examining uncertainties under open access. They are also examining a market model addressing the overlaps in business plans for the DG technology provider, end user, and the wires companies and utilities.	Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Develop software to optimize DER in response to market price signals	Integration of the needs and requirements among parties involved in DG, a better understanding and a model of the market

Funding/Source	Participants	Point of Contact
ABB, Constellation Power Source, Electricité de France (EdF), and TransÉnergie U.S. Ltd. (a subsidiary of Hydro Québec), and the U.S. DOE's Energy Information Administration	MIT Energy Laboratory	Dr. Marija D. Ilic Principal Investigator 617 253 4682 ilic@mit.edu Stephen R. Connors Supporting Investigator 617 253 7985 connorsr@mit.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Modeling	Emerging	Research/Development

Figure 3-14: University of Wisconsin, Pricing Models (4)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is working on developing pricing models to determine the effect of interruptible power programs. Through computer analysis and fieldwork, impact of system reliability as well as providing maximum value to the customer are being examined.	• Do we understand DER's impact of the grid? • Could it be made easier for consumers to maximize their investment in DER? • Can the transaction/ participation costs be reduced for DER?	• Model and analyze the grid with varying levels of DER penetration • Develop software to optimize DER use	Determine the effect of interruptible power pricing on consumers and its impact on system reliability.

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin, CERTS	Fernando Alvarado University of Wisconsin 1415 Engineering Drive Madison, WI 53706

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Modeling	Pacing	Research

Figure 3-15: University of Wisconsin, Location of DG (5)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is conducting a study to determine where on the grid distributed generation would prove to be the most valuable. System considerations and constraints as well as DG's impact on the grid are be examined.	• Do we understand DER's impact of the grid? • Is there a limit to the level of DER that the system can absorb without adverse impacts?	• Model and analyze the grid with varying levels of DER penetration • Demonstrate and test varying levels of DER penetration in a distribution system	Determine where within the grid DG can be placed to maximize its benefits.

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin	Fernando Alvarado University of Wisconsin 1415 Engineering Drive Madison, WI 53706

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Modeling	Pacing	Research

Figure 3-16: University of Wisconsin, Inverter Technologies (6)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is working on one aspect of microgrid technologies with CERTS. The university is looking at increasing the modularity of inverters to help decrease cost and improve reliability. By creating a standard design for inverters engineering time and integration effort should be reduced.	Are their safe, reliable and cost-effective interconnection solutions for radial and networked distribution system?	• Reduce cost of components • Improve reliability and performance of components • Develop standardized products for small DER	Create a standard inverter model that can be connected in parallel to meet varying size needs

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin, CERTS	Giri Venkataramanan 608 262-4479 giri@engr.wisc.edu University of Wisconsin 1415 Engineering Drive Madison, WI 53706

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Pacing	Development

Figure 3-17: University of Wisconsin, Inverter Control Technologies (7)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is examining improving power quality and reliability through operating clusters of inverters. This expensive technology is beneficial for those areas where reliability and power quality is critical.	Are their safe, reliable and cost-effective interconnection solutions for radial and networked distribution system?	• Reduce cost of components • Improve reliability and performance of components	Improving reliability and power quality a group of inverters operating in parallel

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin, NREL	Giri Venkataramanan 608 262-4479 giri@engr.wisc.edu University of Wisconsin 1415 Engineering Drive Madison, WI 53706

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Pacing	Development

Figure 3-18: GTI - Integrated Switchgear and Interconnection Systems (8)

Project/Technology Development/Product	Issues	Strategy	Expected Results
This project is seeking to reduce capital costs by 25-50%, reduce installation time by 50%, conform to basic electric utility interconnection requirements, and begin to incorporate advanced interconnect/generator set protective functions, conform with existing and projected industry standards, and advance remote monitoring, communications and control functions.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection be made more user-friendly for the end user?	•Reduce costs of interconnection componets •Integrate interconnection functions with other DER functions	Reduce and complexity and cost of interconnection and advanced operation of DER equipment

Funding/Source	Participants	Point of Contact
Cost shared among participants	GE Zenith Controls and Gas Technology Instititute	Ted Bronson Gas Technology Institute Assoc. Director of Distributed Generation ted.bronson@gastechnology.org 1700 S. Mt. Prospect Road Des Plaines, 60018-1804 Tel: (847) 768-0637

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Cost Reduction	Key	Commercial

Figure 3-19: GTI - Distributed Energy Technology Development Center (9)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Test facility for equipment connected to the grid •Look into generation and interconnection equipment perfomance and control strategies for DG technologies and products •To demonstrate performance before widespread implementation for utilities and utility coalitions •Began in 2000 and currently expanding capabilities	Is a single DER unit compatible with end-use equipment or other DER equipment?	Test and understand compatibility and power quality issues associated with DER	Improve understanding of equipment that may enter the DER

Funding/Source	Participants	Point of Contact
Cost sharing among participants	GTI, utilities/utility coalitions, FERC	Ted Bronson Gas Technology Institute Assoc. Director of Distributed Generation ted.bronson@gastechnology.org 1700 S. Mt. Prospect Road Des Plaines, 60018-1804 Tel: (847) 768-0637

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Key	Commercial

Figure 3-20: GTI - Remote Monitoring (10)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Monitor the grid and the power output from the units to make comparisons (and how they interact: harmonic disturbances). GTI will help develop the product and provide technical assistance.	Can we understand the information needs of wires companies with DER deployed in their systems?	•Perform analysis of the information and data needs of wires companies •Develop and demonstrate system for wires companies to monitor DER	Increased insight into the nature and feasibility of remotely managed DER to provide reliable, high quality power

Funding/Source	Participants	Point of Contact
Cost shared among participants	GTI and utilities/utility coalitions	Ted Bronson Gas Technology Institute Assoc. Director of Distributed Generation ted.bronson@gastechnology.org 1700 S. Mt. Prospect Road Des Plaines, 60018-1804 Tel: (847) 768-0637

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Power Quality, Power Reliability, Control	Pacing	Development

Figure 3-21: IEEE/P1547 Electric Power Resources Interconnected with the Power System (11)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Providing interconnection standards for connecting to the electric power system and for performance, operation, testing, safety considerations, and maintenance	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion?	Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions	Development of Standard 1547: Standard for Resources Distributed Interconnected with Electric Power Systems

Funding/Source	Participants	Point of Contact
DOE, IEEE	Numerous stakeholders in distributed generation and interconnection	Richard Friedman Resource Dynamics Corp. 703-356-1300 x203

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Testing Certification, Power Quality, Power Reliability, Control	Base	Commercial

Figure 3-22: GE Corporate R&D: DG/Utility System Interconnect (12)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The objectives of this project include: 1. Support IEEE P1547 interconnect working group 2. Set up DG/EPS/ load virtual testbed for long-term research 3. Study of DG power grid safety, reliability, stability, and power quality 3. Identify modifications to existing power systems and DG power electronics 4. Prototyping DG-Grid Interconnection Interface 6. Set up beta test sites 7. Power cost optimization & bulk system operation strategies	• Can engineering studies be eliminated, standardized or streamlined? • Is a single DER unit compatible with end-use equipment or other DER equipment?	•Develop models to understand system impacts •Develop test protocols for compatibility and power quality testing of DER •Test and understand compatibility and power quality issues associated with DER	-Increased insight into major issues around interconnection: safety, power quality and power reliability -Conceptual design of the interconnect by end of first year -Virtual test bed operational by end of first year

Funding/Source	Participants	Point of Contact
DOE	GE Corporate R&D, GE Power Systems Energy Consulting, Puget Sound Energy	Dr. Richard Zhang zhangr@crd.ge.com GE Corporate R&D Building K1, Room 2C33 Niskayuna, NY 12309 Tel: 518-387-5313

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Modeling, Communication, Software, IT	Pacing	Research

Figure 3-23: DTE - Aggregation Model and Field Testing (13)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The Project Team will select & model two of Detroit Edison's distribution circuits and determine the impact of DR connection on circuit voltage and protection equipment .	Can engineering studies be eliminated, standardized, or streamlined?	•Develop models to understand system impacts •Develop software to facilitate impact studies	Supports the work of IEEE SCC21 1547 and proposed testing (analysis + evaluation) requirements

Funding/Source	Participants	Point of Contact
60 %DOE NREL and 40% DTE Energy Technologies	DTE Energy Technologies and Detroit Edison	Murray Davis DTE Energy Technologies (248) 427-2221

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Modeling, Software	Pacing	Research

Figure 3-24: Distributed Utility Integration Test (14)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Large scale effort to examine DER technology and impacts: •Meet NREL/DOE needs for interconnection system integration activities •Plan, site and design Distributed Utility Integration Test (DUIT) •Develop test plan for Distributed Power testing at Nevada Test Site	•Do we understand DER's impact on the grid? •Is there a limit to the level of DER that the ysstem can absorb without adverse impacts? •Are there limitations on bi-directional power? •Can engineering studies be eliminated, standardized or streamlined?	•Model and analyze the grid with varying levels of DER penetration •Develop models to understand system impacts	Increased understanding of electrical issues, control systems, modeling techniques, utility distribution system benefits, and outreach/cooperation

Funding/Source	Participants	Point of Contact
DOE NREL and various participants	Distributed Utility Associates, California Energy Commission, Endecon Engineering, Caterpillar, Solar Turbines, Encorp, Pacific Gas and Electric Co., Exelon (Philadelphia Electric Co.), On-Site Energy, Gas Research Institute	Joseph Iannucci Distributed Utility Associates dua@ix.netcom.com 925-447-0624

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Power Quality, Power Reliability, Congestion	Pacing	Research

Figure 3-25: NiSource - Advanced CHP Systems (15)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Three-phase, multi-year research and development effort to advance distributed power development, deployment, and integration -Develop, test, and optimize several (electric/natural gas/ renewable energy) stand-alone distributed power systems -Develop and initiate laboratory and field tests, methodologies, controls (including command, communications, monitoring, efficiency, and heat rate)	• Can it be made easier for consumers to maximize their investment in DER? • Can interconnection be made more user-friendly to the end-use consumer?	•Develop advanced controls and optimization approaches and technologies •Improve reliability and performance of interconnection components	Advance DER acceptance through ease of use and improved integration using advanced control technologies

Funding/Source	Participants	Point of Contact
DOE	NiSource	Dr. Robert A. Kramer NiSource Energy Technologies Vice President and Chief Scientist Pete Disser (ptdisser@nisource.com) NiSource Energy Technologies Vice President Tel: 219-647-6070

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control, IT	Emerging	Development

Figure 3-26: Electrotek and NYSERDA - Aggregated DG (16)

Project/Technology Development/Product	Issues	Strategy	Expected Results
3 year plan to incorporate distributed generators into the NYSERDA system Base Year: Develop metering/ algorithms/controls; conduct feasibility analyses, and survey backup generators in LIPA territory. Option Year 1: Develop, Install & Conduct Pilot Test; Develop Commercial Design Option Year 2: Procure, Install& Operate a 30 MW commercial aggregation/ dispatch service.	Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Demonstrate aggregation and control of DER	Improved understanding of the extent to which DG can replace/reduce the need for traditional installed capacity in the power grid

Funding/Source	Participants	Point of Contact
DOE NREL and NYSERDA	Electrotek, NYSERDA	Howard Feibus Electrotek Concepts, Inc. howardf@electrotek.com 703-655-7105

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	IT, Control, Communication	Key/Pacing	Demonstration

Figure 3-27: NRECA – Evaluation of the Field Performance of Fuel Cells (17)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Field testing of different fuel cells for rural power applications to improve understanding of the potential benefits (e.g., improved reliability and reduced service cost, grid support for rural feeders, and reduced cost to serve remote locations) and barriers: (e.g., high cost of equipment, permitting, safety, and interconnection) and provide technology benchmark for future action	Do we understand DER's impact on the grid?	Demonstrate and test varying levels of DER penetration in a distributed system	Increased insight into the applicability and appropriateness of fuel cells to serve rural and remote communities in lieu of or as a backup for grid connected power

Funding/Source	Participants	Point of Contact
DOE NREL-up to $290,000 based on milestones over 3 years	National Rural Electric Cooperative Association (NRECA)- Cooperative Research Network	Edward Torrero ed.torrero@nreca.org 4301 Wilson Blvd. SS9-204 Arlington, VA 22203 Tel: (703) 907-5624

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Power Quality, Power Reliability	Key	Demonstration

Figure 3-28: NRECA – Evaluation of the Microturbines (18)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Field testing of different microturbines for rural power applications to improve understanding of the potential benefits (e.g., improved reliability and reduced service cost, grid support for rural feeders, and reduced cost to serve remote locations) and barriers: (e.g., high cost of equipment, permitting, safety, and interconnection) and provide technology benchmark for future action	Do we understand DER's impact on the grid?	Demonstrate and test varying levels of DER penetration in a distributed system	Increased insight into the applicability and appropriateness of microturbines to serve rural and remote communities in lieu of or as a backup for grid connected power

Funding/Source	Participants	Point of Contact
DOE Oak Ridge National Lab-up to $200,000 based on milestones over 3 years	National Rural Electric Cooperative Association (NRECA)- Cooperative Research Network	Edward Torrero ed.torrero@nreca.org 4301 Wilson Blvd. SS9-204 Arlington, VA 22203 Tel: (703) 907-5624

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Power Quality, Power Reliability	Key	Demonstration

Figure 3-29: Industrial DG, Varying Load (19)

Project/Technology Development/Product	Issues	Strategy	Expected Results
•Mitigate the impact highly varying loads have on power system generation control •Involves modeling / predicting power system Area Control Error and load control flexibility •Initially working with an arc furnace, extending project to a rolling mill and then multiple steel facilities	Can interconnection solutions be deployed in a timely fashion?	Improve reliability and performance of interconnection components	Increase insight into the ability of DG controls to cope with highly varying loads for industrial applications

Funding/Source	Participants	Point of Contact
$342,000 DOE Share first year (3 years in total), DOE OPT and OIT	Northern Indiana Public Service Co. (Bob Kramer), Purdue University, Colorado School of Mines, Steel mill	Mike Karnitz, Oak Ridge National Laboratory

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Modeling, Hardware	Key	Demonstration

Figure 3-30: GTI & ENCORP - Innovative Interconnections (20)

Project/Technology Development/Product	Issues	Strategy	Expected Results
•Cost-effective DER grid interconnection products, software and communication •Improved economics for broad range of DER power systems •Enhanced DER product capability to integrate, interact, and provide operational benefits •Building energy mgmt. system and electric power systems •Resource planning, ancillary services, and load/demand management	Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	•Develop low cost communications and control •Develop software to optimize DER in response to market price signals	Cost-effective interconnection and control solutions will make DER power solutions more feasible and attractive

Funding/Source	Participants	Point of Contact
DOE	GTI and ENCORP	William Liss Gas Technology Instititute (847) 768-0753 William Saylor ENCORP

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	IT, Software, Metering, Control/Dispatch, Communications	Key	Demonstration

Figure 3-31: Kelso Starrs and Associates - Interconnection Barriers (21)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Through surveys and interviews with DG facility developers and owners, a list of problems encountered while interconnecting their equipment will be developed and categorized	Can interconnection solutions be made more user-friendly to the end-consumer user?	Understand impact of new interconnection requirement; Identify best practices for interconnection	A summary of current barriers and some preliminary conclusions regarding potential steps for overcoming these barriers

Funding/Source	Participants	Point of Contact
DOE	Kelso Starrs and Associates	Tom Starrs Kelso Starrs and Associates 14502 SW Reddings Beach Road Vashon, WA 98070 Tel: 206-463-7571

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Policy	Base	Commercial

Figure 3-32: Regulatory Assistance Project (22)

Project/Technology Development/Product	Issues	Strategy	Expected Results
-Write and publish four papers for regulatory audience •Simplified costing methods for distribution systems •Develop system for de-averaged distribution credits •Case studies for DER and reliability •Options to incorporate DER in wholesale markets -Organize and deliver two workshops to state regulators -Organize and participate in national working group on model rule for DER emission performance standard	• Can market rules be modified to allow DER to participate in current markets? • Are there tariffs or rates that could be crafted to provide better price transparency for DER?	• Assess current wholesale market rules for applicability to DER •Assess requirements for tariffs or rates	Additional information to help reveal the value of DER to customers, distribution companies, wholesale market participants and regulations.

Funding/Source	Participants	Point of Contact
DOE	Regulatory Assistance Project	Cheryl Harrington Regulatory Assistance Project rapmaine@rapmaine.org

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Wholesale, Policy	Pacing / Key	Commercial

Figure 3-33: Urban Consortium Energy Task Force (23)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Educate 50 of the largest cities and counties on Distributed Generation issues and technologies; Participate in solving local government barriers to Distributed Generation; Investigate aggregate purchasing power of Local Govts for Distributed Generation products; Act as resource for local governments on Distributed Generation Issues.	Can interconnection solutions be deployed in a timely fashion?	Educate stakeholders on new requirements, contracts and processes	Increased understanding and adoption of DER solutions to challenges in cities across the US

Funding/Source	Participants	Point of Contact
DOE and task force members	Urban Consortium Energy Task Force and member cities	Roger Duncan Austin Energy roger.duncan@austinenergy.com sbrown@pti.nw.dc.us (800) 852-4934

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Policy	Base	Commercial

Figure 3-34: UL 1741 (24)

Project/Technology Development/Product	Issues	Strategy	Expected Results
UL1741: Standard for Inverters Converters and Controllers for use in Independent Power Systems. UL 1741 is the standard to which photovoltaic, fuelcell, microturbine and wind turbine inverters and converters are evaluated for electrical safety and many utility interconnection requirements	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion?	Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions	UL1741 as a standard to assist in harmonizing the different stakeholders and technologies.

Funding/Source	Participants	Point of Contact
Various stakeholders	Underwriters Laboratories and various stakeholders in DER	Tim Zgonena Senior Project Engineer Email: timothy.p.zgonena@us.ul.com Address: 333 Pfingsten Rd. Northbrook, IL 60062

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Testing Certification, Power Quality, Power Reliability	Base	Commercial

Figure 3-35: Rule 21 (25)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Activities (e.g., workshops and case studies) to help create interconnection standards for DER and streamline permitting in the state of California to ensure the safety and quality of the power supply before more universal standards are adopted. 12 case studies will be prepared that examine DER project in terms of processes and their impact on the grid.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion? • Do we understand DER's impact on the grid?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Model and analyze the grid with varying levels of DER penetration	Increase clarity on interconnection requirements and simpler permitting processes for DER equipment in California

Funding/Source	Participants	Point of Contact
California Energy Commission	California Energy Commission, Overdomain, Reflective Energies, and various stakeholders in DER	Cris Cooley Overdomain ccooley@overdomain.com Tel: 805.683.0938 Edan Prabhu Reflective Energies edanprabhu@home.com

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Power Quality, Power Reliability	Base	Commercial

Figure 3-36: UC, Irvine - Unified Control Inverter (26)

Project/Technology Development/Product	Issues	Strategy	Expected Results
University of California, Irvine has developed the Unified Control Inverter. A patented inverter technology with improved stability and power quality with better performance particularly at part load	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system?	• Reduce costs of interconnection components • Improve reliability and performance of interconnection components (e.g., power electronics)	A low cost, improved dynamic range performance inverter for microturbines, photovoltaics and fuel cells

Funding/Source	Participants	Point of Contact
University of California, Irvine Internally funded project	University of California, Irvine	Jack Brouwer: jb@nfcrc.uci.edu National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 Phone (949) 824-1999 x221 Fax (949) 824-7423

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Key	Development

Figure 3-37: UC, Irvine – Microgrids (27)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of California, Irvine research park was built "DG ready" and has a distribution system that can be easily modified to test the impact of DG on different distribution system configurations.	• Do we understand DER's impact on the grid? • Can microgrids be utilized effectively?	• Demonstrate and test varying levels of DER penetration in a distribution system • Modify distribution system design approaches • Demonstrate and test microgrids • Develop design guidelines for microgrids	Better understanding on the interaction of DG and its impact in a microgrid

Funding/Source	Participants	Point of Contact
Not currently funded	University of California, Irvine	Jack Brouwer: jb@nfcrc.uci.edu National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 Phone (949) 824-1999 x221 Fax (949) 824-7423

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Microgrids	Key	Development/Demonstration

Figure 3-38: UC, Irvine - Interconnection Design (28)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The National Fuel Cell Research Center has been interconnecting microturbines with the SCE distribution system, They have developed insight into reducing the cost of interconnection by removing unnecessary requirements and standardizing designs.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Standardize designs around new requirements	Low cost interconnection and simplified interconnection agreements

Funding/Source	Participants	Point of Contact
Internally funded	University of California, Irvine	Jack Brouwer: jb@nfcrc.uci.edu National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 Phone (949) 824-1999 x221 Fax (949) 824-7423

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Base	Commercial

Figure 3-39: UC, Irvine - SCAQMD Microturbine Demonstration (29)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The South Coast Air Quality Management District (SCAQMD) is installing 200 Capstone microturbines in the SCAQMD. National Fuel Cell Research Center is assisting SCAQMD with an operating strategy that includes identifying communications, control and software requirements.	• Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)? • Can it be made easier for consumers to maximize their investment in DER?	• Demonstrate aggregation and control of DER • Develop low cost metering • Develop low cost communications and control • Develop software to optimize DER in response to market price signals	Understanding of the optimum control and operating strategy as well as the advantages and disadvantages of different communication paths and transaction verification

Funding/Source	Participants	Point of Contact
SCAQMD-$100k	University of California, Irvine, Real Energy, Silicon Energy, Connectisys	Jack Brouwer: jb@nfcrc.uci.edu National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 Phone (949) 824-1999 x221 Fax (949) 824-7423

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Communications/Control	Pacing	Demonstration

Figure 3-40: EPRI - IEEE P1547 (30)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI is supporting the IEEE P1547 effort. Additional activities include in-house training for utility staffs and state level education on the standard and its implications	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Educate stakeholders on new requirements, contracts and processes	Timely adoption of IEEE P1547 standard

Funding/Source	Participants	Point of Contact
EPRI base and tailored collaboration funding	EPRI	Dan Rastler EPRI Solutions 3412 Hillview Ave., Palo Alto, CA 94304 650.855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Power Quality, Power Reliability, Control Systems	Base	Commercial

Figure 3-41: EPRI - Completing the Circuit (31)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRISolutions' Completing the Circuit offering is a coordinated series of five projects to solve the complex technical issues currently preventing or delaying interconnection of DER. The following five projects will test and certify DER equipment and solve specific compatibility problems: • Laboratory trials of Proposed IEEE P1547 • Certification of Grid-Connected DER • System compatibility testing of DG and energy storage for end-use applications • Dynamic interaction of various interconnected devices for end-use applications • Prevention of unintentional islanding of DER	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion? • Is a single DER unit compatible with end-use equipment or other DER equipment? • Do we understand DER's impact on the grid?	• Understand impact of and adopt new interconnection requirement • Type testing and certification of interconnection solutions • Develop guidelines and best practices for interconnection • Develop test protocols for compatibility and power quality testing of DER • Test and understand compatibility and power quality issues associated with DER	Practical steps to facilitate the reliable, cost-effective and safe interconnection of DER and thereby make the benefits of DER possible. Participants in this collaborative project will benefit by having their investment leveraged and used to address important interconnection issues that otherwise would have to be addressed and funded by individual utilities.

Funding/Source	Participants	Point of Contact
$500k over multiple years from participating energy companies	The research will be conducted by EPRI PEAC which operates test facilities including a Power Quality Test Facility and a Power Quality Distributed Resources Park	EPRI Bill Steely (650) 855-2203 Ben Banerjee (650) 855-7925

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection, Grid Impacts	Interconnection and Power Quality	Base	Commercial

Figure 3-42: EPRI - DER Engineering Guide and Workstation (32)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI is developing an engineering guide and workstation to better integrate DER with the distribution system. The software is a "how-to" guide to apply P1547 and also includes communications and control issues and system impacts.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system? • Can interconnection solutions de deployed in a timely fashion? • Do we understand DER's impact on the grid? • Should distribution design philosophy be modified to accommodate DER? • Can engineering studies be eliminated, standardized or streamlined?	• Understand impact of and adopt new interconnection requirement • Develop models and software to facilitate impact studies	Step by step primer and workstation for enhanced DER system integration engineering

Funding/Source	Participants	Point of Contact
Tailored collaboration to be completed in 2001. Included in DR base program funding.	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave., Palo Alto, CA 94304 650.855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection, Grid Impacts	Interconnection and Power Quality	Base	Development/ Demonstration

Figure 3-43: EPRI - Development of DR Micrigrids (33)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI Technical Assessment:: Development of Distributed Resources Micro-Grids	Can micrigrids be utilized effectively?	• Model and analyze microgrids • Develop design guidelines for microgrids	Better understanding of the potential and pitfalls of small-scale distribution systems with embedded DER

Funding/Source	Participants	Point of Contact
Tailored collaboration to be in 2001. Included in DR base program funding.	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave., Palo Alto, CA 94304 650.855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Micro-grids	Key	Development

Figure 3-44: EPRI - System Modeling for DR Impacts (34)

Project/Technology Development/Product	Issues	Strategy	Expected Results
System modeling to determine distributed resources impact on distribution systems	• Do we understand DER's impact on the grid? • Can engineering studies be eliminated, standardized or streamlined?	• Model and analyze the grid with varying levels of DER penetration • Develop models and software to facilitate impact studies	Data set for modeling distributed resources in electric power system simulations

Funding/Source	Participants	Point of Contact
Tailored collaboration completed in 2000. Included in DR base program funding.	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave., Palo Alto, CA 94304 650.855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Modeling	Base	Development/ Demonstration

Figure 3-45: EPRI - Interconnection Hardware (35)

Project/Technology Development/Product	Issues	Strategy	Expected Results
A breakthrough low cost interface box	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution system?	Develop new technologies that would eliminate or reduce some requirements or costs of interconnection	Lower cost interconnection

Funding/Source	Participants	Point of Contact
$150k. Included in DR base program funding.	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave., Palo Alto, CA 94304 650.855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Modeling	Base	Development/ Demonstration

Figure 3-46: EPRI - DER status and condition information system (36)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI is developing a hardware and software system for utility control centers to identify DER resources located in the utilities system and understand the status of these resources	Can we understand the information needs of wires companies with DER deployed in their systems?	• Perform analysis of the information and data needs of wires companies • Develop and demonstrate system for wires companies to monitor DER	Prototype of the system

Funding/Source	Participants	Point of Contact
Prototype system is included in this year's base funding. Demos will require additional funding.	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave., Palo Alto, CA 94304 650.855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Impacts	Software and Hardware	Pacing	Development/ Demonstration

Figure 3-47: Alternative Energy Systems Consulting - Smart*DER (37)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Smart*DER - Intelligent Software Agents for Control and Scheduling of Distributed Energy Resources. An intelligent agent is a software-based device that acts on behalf of the end-user and has the ability to exploit knowledge, learn and reason and communicate. Intelligent software agents and their ability to collaborate make them well suited to the task of controlling and scheduling large number of DER assets.	• Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)	The Phase I effort addressed the difficulty in introducing the DER paradigm to the power industry, demonstrated the viability of this approach and provided demonstration software to facilitate technology transfer. Phase II moves the technology further along the development path and addresses issues related to selecting the correct commercialization path for moving this technology to the marketplace.

Funding/Source	Participants	Point of Contact
Phase II - $500k (15-18 months) CEC PIER Program	Alternative Energy Systems Consulting Reticular Systems Inc. CEC	Gerald Gibson Program Manager Alternative Energy Systems Consulting (AESC) 4715 Viewridge Avenue, Suite 200, San Diego, CA 92123 and 1945 Camino Vida Roble, Suite A, Carlsbad, CA 92008

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Emerging	Development/Demonstration

Figure 3-48: DENNIS (38)

Project/Technology Development/Product	Issues	Strategy	Expected Results
A 3 year effort to produce a controller and demonstrate the ability of a group of controllers to operate through a neural network to provide a smart, technologically sophisticated, but simple, efficient and economic solution for aggregating a community of small distributed generators into a virtual single large generator capable of selling power internally or externally to a utility, ISO or other entity, in a coordinated manner.	• Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)	Program will result in an energy integration product for residential, commercial and industrial distributed generation applications.

Funding/Source	Participants	Point of Contact
Currently in the first year of a 3-year project ($500k) DOE	Orion Engineering Corporation and University of Massachusetts at Lowell	Herb Sinnock, 617.625.3953 Tom Regan, 978.337.1352 Orion Engineering Corporation 40 Marion Street, Sommerville, MA 02143

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Emerging	Development

Figure 3-49: Pleasanton Power Park (39)

Project/Technology Development/Product	Issues	Strategy	Expected Results
RealEnergy is developing the Pleasanton Power Park, a 19-acre industrial park located in Pleasanton, CA. RealEnergy will install a variety of DER technologies to allow the park to generate its own supply of electricity. Silicon Energy's Enterprise Energy Management software will manage the deployment, aggregation and control of the DER units using the Distributed Energy Manager (DEM) software.	• Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	• Demonstrate aggregation and control of DER • Develop low cost communications and control • Develop software to optimize DER in response to market price signals	The Silicon Energy software will optimize costs by collecting and processing data that will allow a central control system to manage the park's energy demand and resources

Funding/Source	Participants	Point of Contact
Project is cost-shared between CEC & DOE ($1.7MM for solar installation), RealEnergy and Silicon Energy	CEC, DOE, RealEnergy and Silicon Energy	Steven Greenberg (sgreenberg@realenergy.net) 300 Capitol Mall, Ste 120, Sacramento, CA 95814 916-325-2500 x108

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Key/Pacing	Development/Demonstration

Figure 3-50: Sixth Dimension (40)

Project/Technology Development/Product	Issues	Strategy	Expected Results
In Summer of 2000, Sixth Dimension and New West Energy implemented an Internet-based solution to curtail peak-power loads and bid sheddable loads into real-time energy markets through California's Independent System Operator (ISO).	• Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	• Demonstrate aggregation and control of DER • Develop low cost communications and control • Develop software to optimize DER in response to market price signals	This system allowed communication of real-time, on-site power-meter readings and dispatch signals--via the Internet--between California energy service providers, energy users, and the California ISO. Sixth Dimension's secure Internet network-- 6D iNET™--coupled with its Aggregated Load Curtailment Service Package will provided the California ISO a 4-second snapshot of the power usage at connected sites.

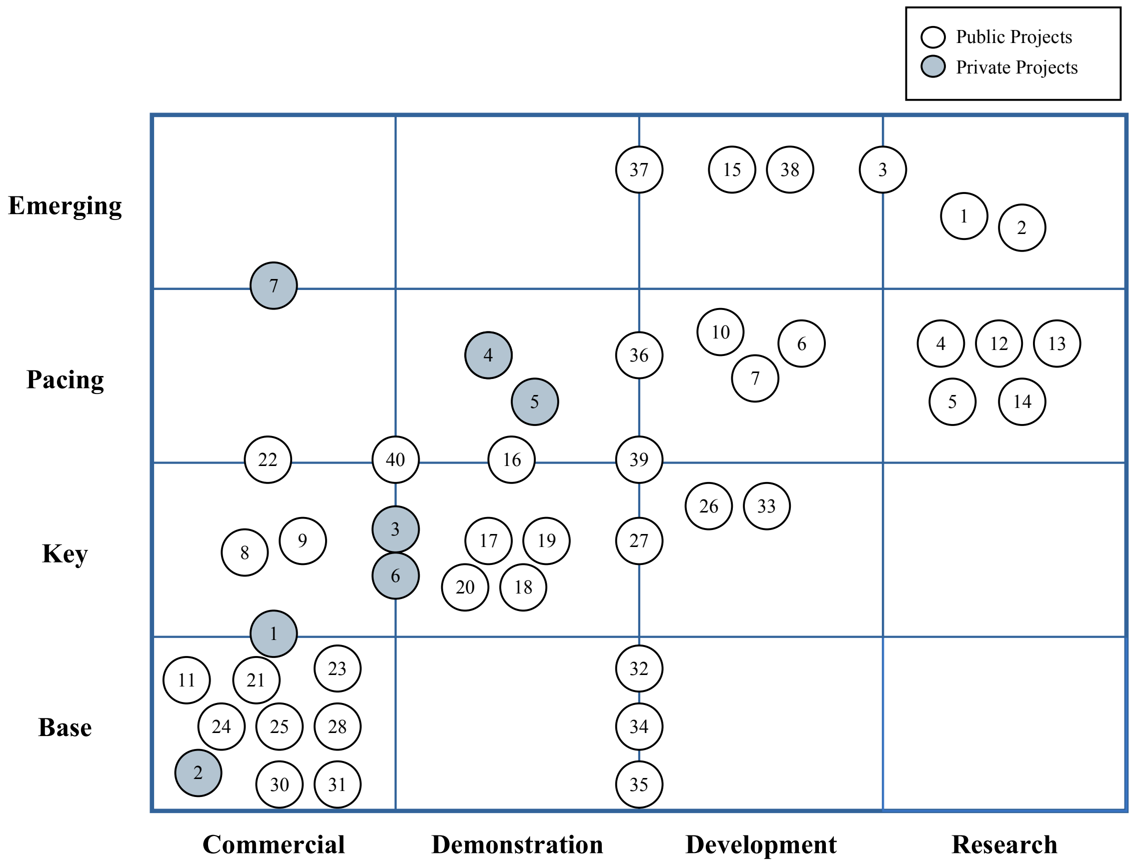
Funding/Source	Participants	Point of Contact
Project is complete	Sixth Dimension, New West Energy, Cal-ISO	Wade Troxell Sixth Dimension 1201 Oakridge Drive, Suite 300 Fort Collins, Colorado 80525 970-267-2021

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Key/Pacing	Demonstration/ Commercial

Overall Current Activity

There is a significant amount of activity in both the private and public sectors (Figure 3-51). Private sector technology development tends to fall in the later phases of the technology development chain; while publicly sponsored research is scattered focused on research and development of emerging and pacing technologies and demonstration and commercialization of key and base technologies.

Figure 3-51: Development and Competitive Status of Public and Private Projects



Chapter 4: Gaps in Strategies

Approach

In this chapter, gaps are identified for each of the strategies found in Chapter 2 based on the current projects from Chapter 3. Gaps are defined as disparities between the current level of private/public activity and the required level of activity to ensure a strategy has a reasonable chance for success at resolving the issue it is addressing.

The strategies were first plotted by their position on the technology development chain (research, development, demonstration and/or commercialization) and the competitive impact of that strategy (base, key, pacing or emerging). Interviews with researchers and company representatives working on these strategies provided the baseline information for assessing gaps. The magnitude of the gap for each strategy is based on the amount and thoroughness of the research pursuing a particular strategy. The following framework was used:

Significant gap – Few companies or entities are adequately pursuing this strategy at a level that will likely ensure the strategy has a reasonable chance of success to help resolve the issue it is addressing. This could indicate an area that has been overlooked or just emerging as a viable strategy. However, it may be a strategy that is not appropriate or feasible to pursue at this time.

Moderate gap – There are several companies and/or entities pursuing this strategy. Continued *and* additional activity is likely required to ensure the strategy has a reasonable chance of success to help resolve the issue it is addressing.

Little or no gap – There are many companies and/or entities pursuing this strategy. The current level of activity is likely appropriate to ensure the strategy has a reasonable chance of success to help resolve the issue it is addressing. *Little* additional work beyond what is currently funded is necessary.

These gaps will be validated or otherwise modified during the public workshop on August 28, 2001. It is important to note that at this time no attempt has been made to place priorities on these strategies and their related gaps. Prioritization will take place during and after the public workshop on August 28, 2001.

Results

The gaps were examined from the public and private perspectives, and then combined for an overall view for each of the three areas: interconnection, grid impacts and market integration.

Interconnection

With respect to interconnection, most of the strategies that were identified in Chapter 2 fall in the range of commercial activities that concern either key or base technologies (Figure 4-1). These strategies deal mostly with:

- Standardizing requirements and processes
- Adopting these new requirements and processes and
- Developing new products based on these new requirements that will lower costs

Strategies in the demonstration area involve the demonstration and field testing of interconnection solutions based on new requirements to better understand their impact. An additional strategy in demonstration is the testing of DG technologies to understand their compatibility with end-use equipment and their impact on power quality.

There are several strategies that fall in the development stage. These activities are longer term and would require other developments prior to being undertaken including:

- Development of smaller DER products
- Further modifications of products and requirements based on field testing and experience
- Longer range development of interconnection technologies

ADL found no strategies that fit in the research area.

Most of the strategies identified involve base or key technologies. Many interconnection technologies have been commercially available for decades and have been widely used in customer self-generation projects. Strategies that are characterized as base are not likely to give any one competitor significant advantage but are essential to the overall success of all interconnection suppliers. Many strategies relying on key technologies are being pursued that could lead to some competitive advantage in the short term.

Figure 4-1: Strategies Addressing Interconnection Issues

Interconnection

Can a substantial amount of DER be interconnected in both radial and networked distribution systems?

Strategies

Standardization and Adoption of New Requirements and Processes

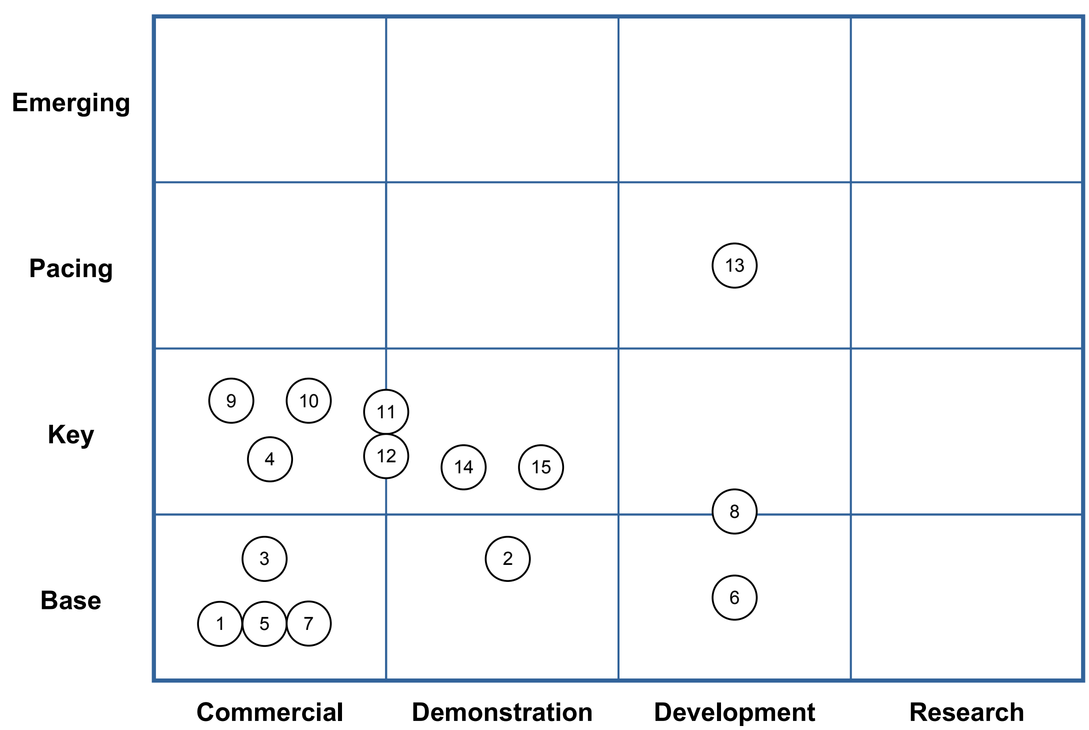
1 Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2 Understand impact of and adopt new interconnection requirement
3 Standardize designs around new requirements
4 Type testing and certification of interconnection solutions
5 Develop guidelines and best practices for interconnection
6 Modify standardized requirements and standardized designs based on modeling, testing and field experience
7 Educate stakeholders on new requirements, contracts and processes
8 Develop standardized products for small DER

Cost Reduction and Product Improvement

9 Reduce costs of interconnection components
10 Improve reliability and performance of interconnection components (e.g., power electronics)
11 Integrate interconnection functions with other DER functions
12 Turnkey solutions that integrate DER functions
13 Develop new technologies that would eliminate or reduce some requirements or costs of interconnection

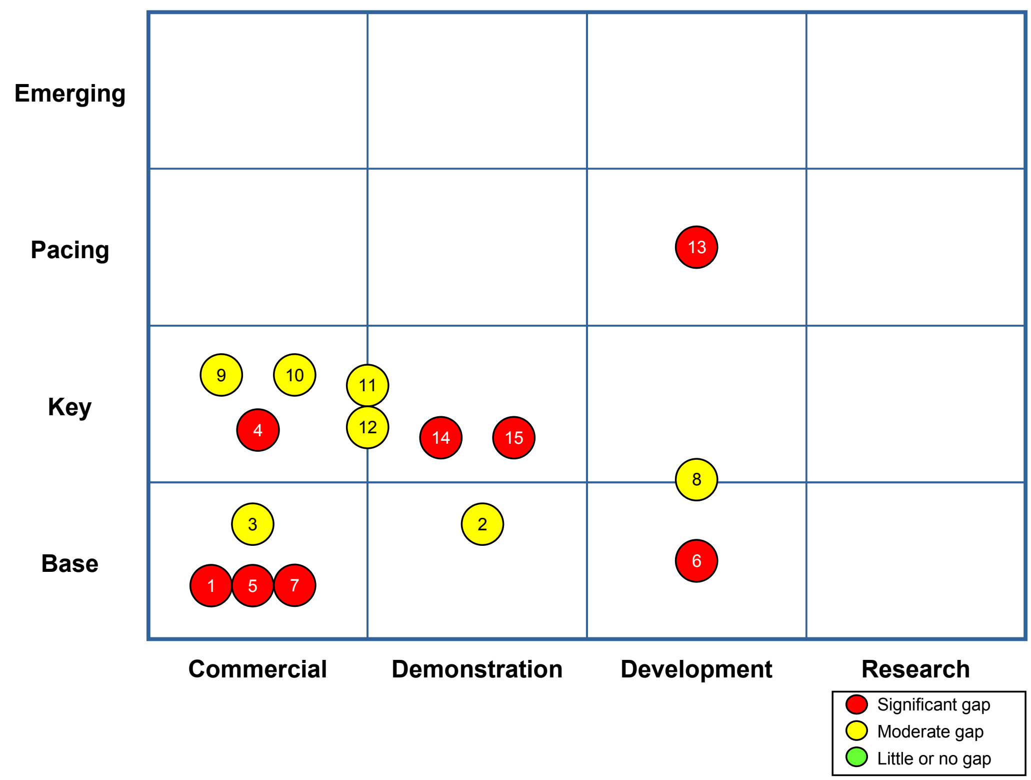
Compatibility

14 Develop test protocols for compatibility and power quality testing of DER
15 Test and understand compatibility and power quality issues



Private companies are deploying strategies that are associated with adopting new requirements and developing products that will reduce the cost of interconnection (Figure 4-2). Ongoing commercial work has been addressing cost reductions through reducing cost of components, turnkey solutions and integrating functions. This activity has been pursued only moderately as the technical requirements are still under development. The private sector work is mostly in the commercial stage of technology development. Companies are deploying base strategies to remain competitive while focusing on key technologies for a longer-term competitive advantage.

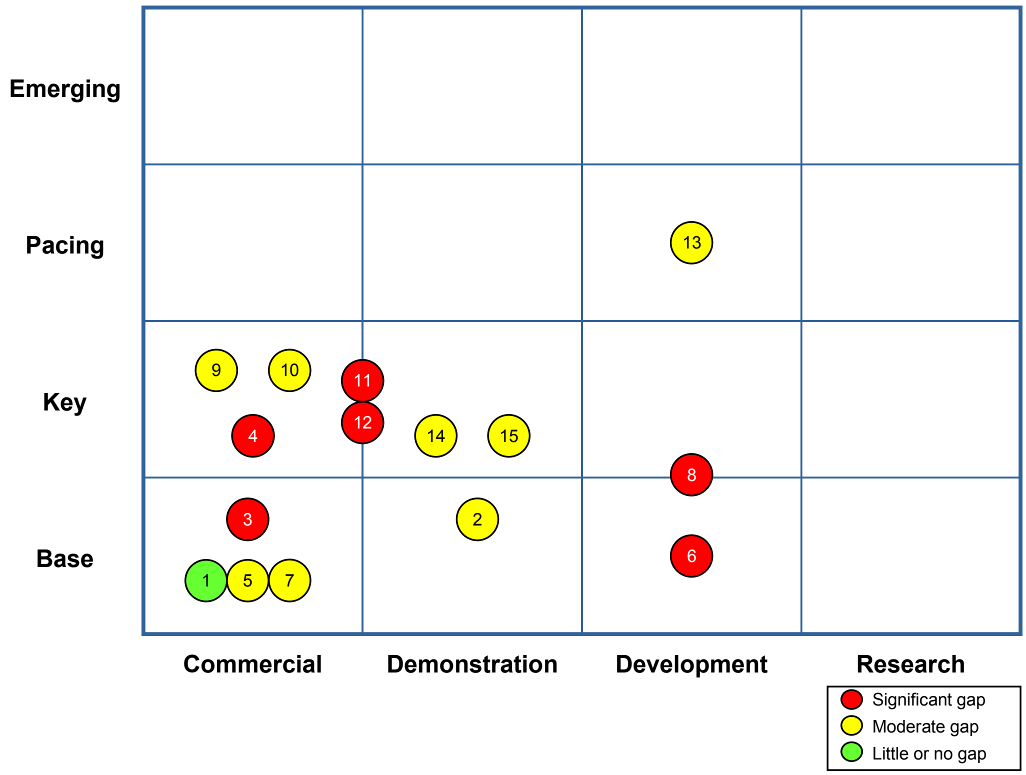
Figure 4-2: Private Activity Deploying Interconnection Strategies



Strategies
Standardization and Adoption of New Requirements and Processes
1 Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2 Understand impact of and adopt new interconnection requirement
3 Standardize designs around new requirements
4 Type testing and certification of interconnection solutions
5 Develop guidelines and best practices for interconnection
6 Modify standardized requirements and standardized designs based on modeling, testing and field experience
7 Educate stakeholders on new requirements, contracts and processes
8 Develop standardized products for small DER
Cost Reduction and Product Improvement
9 Reduce costs of interconnection components
10 Improve reliability and performance of interconnection components (e.g., power electronics)
11 Integrate interconnection functions with other DER functions
12 Turnkey solutions that integrate DER functions
13 Develop new technologies that would eliminate or reduce some requirements or costs of interconnection
Compatibility
14 Develop test protocols for compatibility and power quality testing of DER
15 Test and understand compatibility and power quality issues

Other strategies such as the modification and adoption of new requirements require a collaborative approach supported by public or non-profit entities (Figure 4-3). This would include the development of standards such as the IEEE P1547 and the Rule 21 efforts. The consensus during the interview process was that, while there was still work to be done in the development of standards, level of effort and current standards in California adequately covered this area. Many interviewed expressed that it was time to start focusing beyond the development of these standards to adopting them. There is already some activity in this base/commercial area. Other government/non-profit activity is found in the key/base area where entities such as EPRI are working through testing and demonstration to understand the impact of DER on other end-use equipment. There is also activity in the pacing/development area that would develop new technologies.

Figure 4-3: Public/Non-Profit Activity Deploying Interconnection Strategies



Strategies
Standardization and Adoption of New Requirements and Processes
1 Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2 Understand impact of and adopt new interconnection requirement
3 Standardize designs around new requirements
4 Type testing and certification of interconnection solutions
5 Develop guidelines and best practices for interconnection
6 Modify standardized requirements and standardized designs based on modeling, testing and field experience
7 Educate stakeholders on new requirements, contracts and processes
8 Develop standardized products for small DER
Cost Reduction and Product Improvement
9 Reduce costs of interconnection components
10 Improve reliability and performance of interconnection components (e.g., power electronics)
11 Integrate interconnection functions with other DER functions
12 Turnkey solutions that integrate DER functions
13 Develop new technologies that would eliminate or reduce some requirements or costs of interconnection
Compatibility
14 Develop test protocols for compatibility and power quality testing of DER
15 Test and understand compatibility and power quality issues

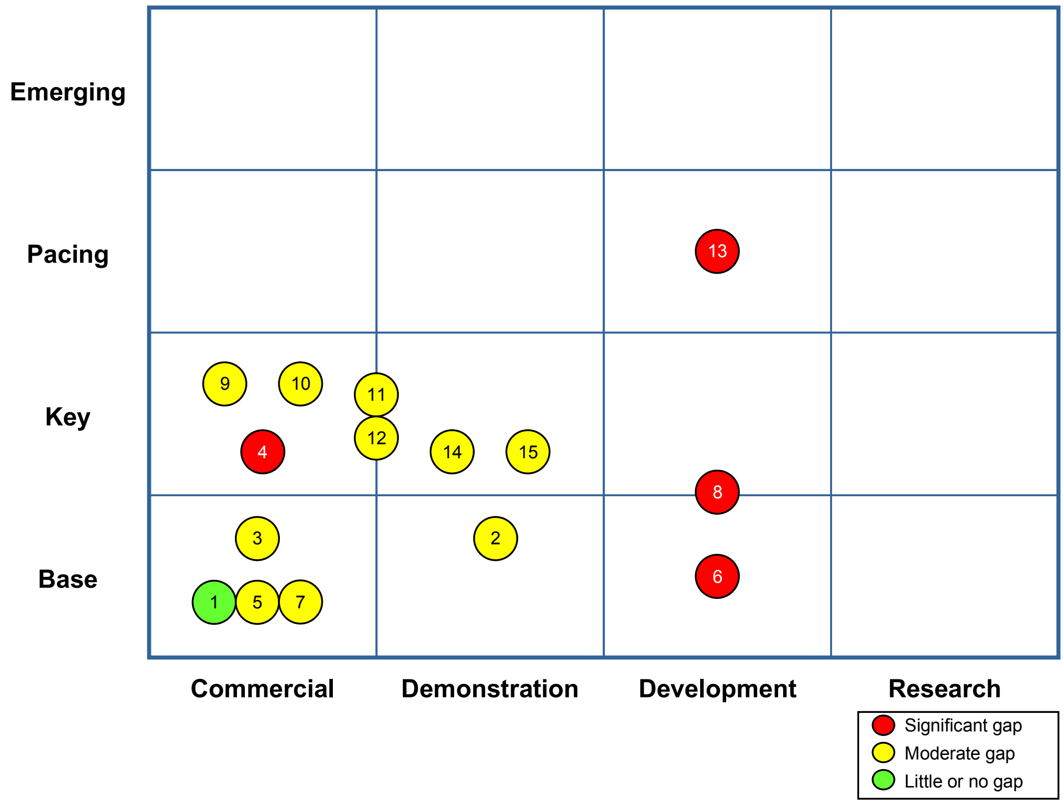
By combining the overall activity the following preliminary observations can be made concerning gaps in the four strategic thrusts (Figure 4-4):

- ***Standardization and adoption of new requirements and processes*** – Strategies in this thrust are focused on base technologies, as there will be little competitive advantage to be gained by any one company with the development and adoption of new standards. There has been a significant amount of activity in California and on a national level in developing standards in the past and going forward, leaving virtually no gap. There are, however, moderate gaps in the strategies that will adopt and refine these standards. Significant gaps exist in type testing and certification. There are also significant gaps in modifying these new requirements and developing standardized products for small DER; however it may be premature to pursue these strategies at this time.

- ***Cost reduction and product improvement*** – Most of the strategies in cost reduction and product improvement are focused on key technologies that are likely to yield competitive advantage for the companies engaged in these activities. There are some companies and government funded activities in this area, but moderate gaps still exist. There is a significant gap in pursuing truly breakthrough technologies that could lead to substantial cost reductions. It is not clear if these breakthrough opportunities exist, but a preliminary study may be warranted.

- ***Compatibility*** – Strategies in compatibility are being pursued exclusively by EPRI PEAC. These activities are just getting underway and additional work is probably required to ensure the success of these strategies.

Figure 4-4: Overall Activity Deploying Interconnection Strategies



Strategies

Standardization and Adoption of New Requirements and Processes

1 Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2 Understand impact of and adopt new interconnection requirement
3 Standardize designs around new requirements
4 Type testing and certification of interconnection solutions
5 Develop guidelines and best practices for interconnection
6 Modify standardized requirements and standardized designs based on modeling, testing and field experience
7 Educate stakeholders on new requirements, contracts and processes
8 Develop standardized products for small DER

Cost Reduction and Product Improvement

9 Reduce costs of interconnection components
10 Improve reliability and performance of interconnection components (e.g., power electronics)
11 Integrate interconnection functions with other DER functions
12 Turnkey solutions that integrate DER functions
13 Develop new technologies that would eliminate or reduce some requirements or costs of interconnection

Compatibility

14 Develop test protocols for compatibility and power quality testing of DER
15 Test and understand compatibility and power quality issues

Grid Impacts

Strategies related to grid impacts span the technology development chain (Figure 4-5). Much of the current work focuses on research and development. However, these technologies will eventually progress to demonstration and commercialization. The competitive impact of this technology development is in the pacing and emerging areas. Some strategies such as understanding grid impacts, changing impact study requirements and understanding and satisfying wires companies' DER information needs are pacing technology development. Although they are not fully embodied in current products, they may, if successfully applied, have a substantial impact on the bases of competition in the reasonably near future.

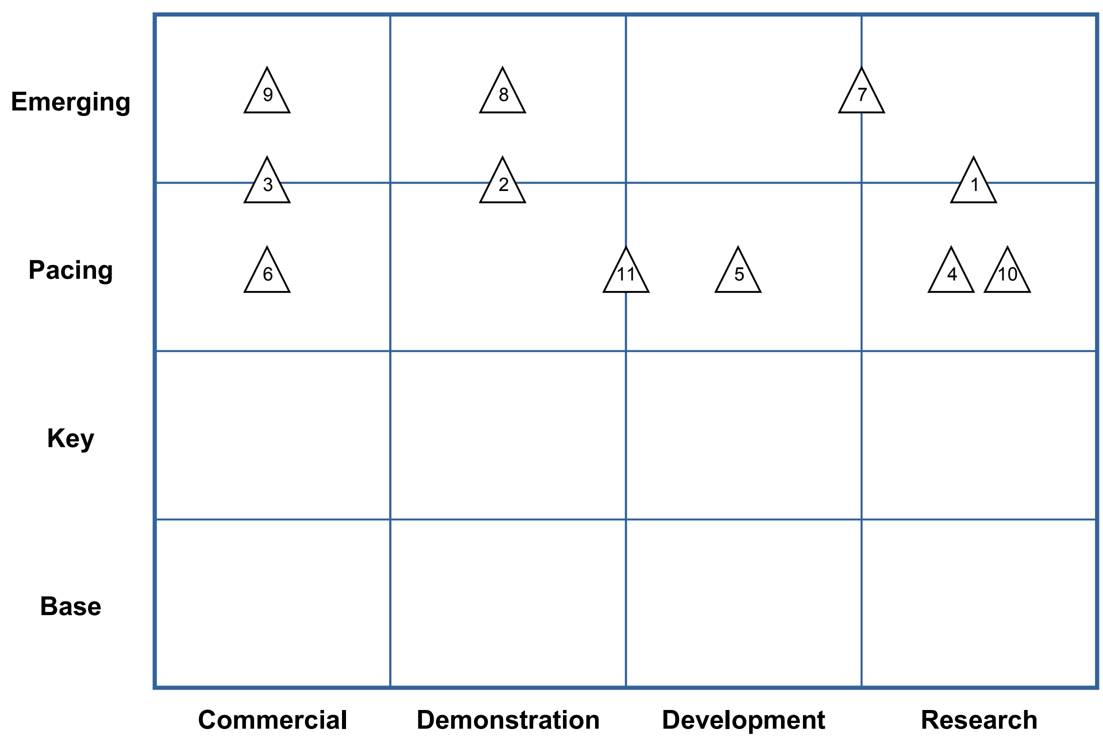
Understanding penetration limits and changing the distribution system design approach to allow for DER could certainly lead to a change in the competitive structure of the industry and perhaps lead to a paradigm shift in how electricity is generated and distributed. However, the ultimate impact is uncertain. Likewise, the impact of microgrids could be are very similar, however the ultimate impact is even less certain.

Figure 4-5: Strategies Addressing Grid Impacts

Grid Impacts

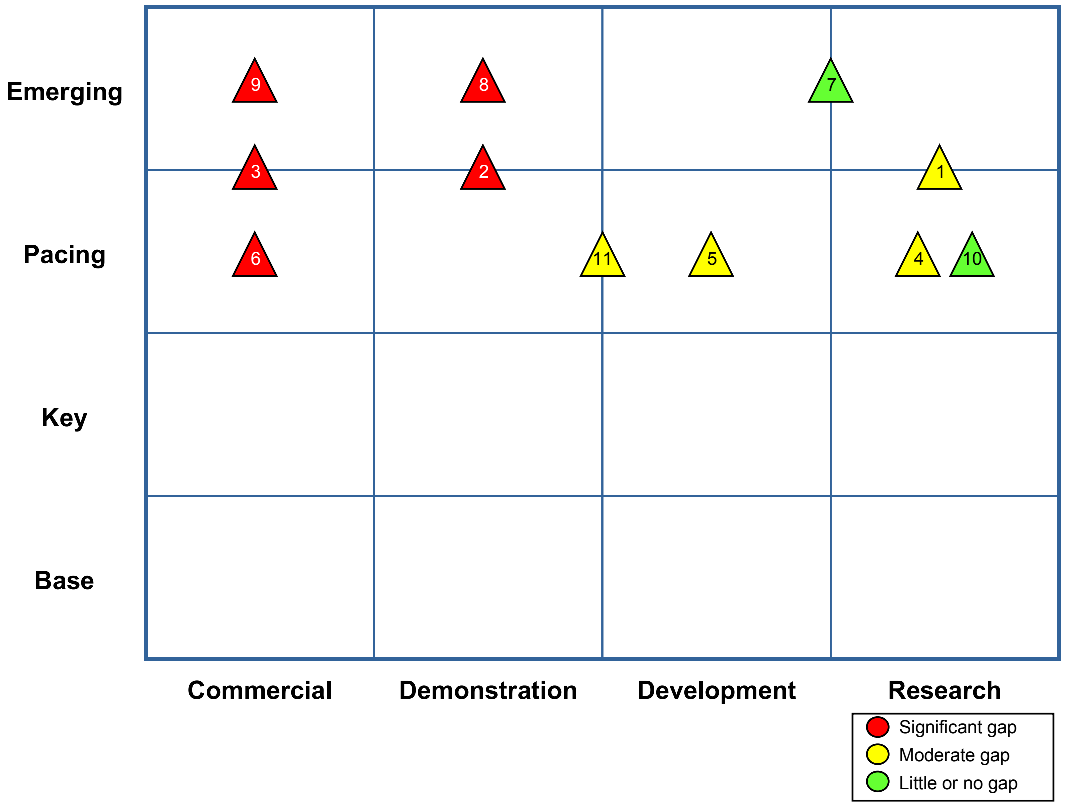
Would a high penetration of DER have adverse impacts on the T&D system?

Strategies
Modeling and Testing
1 Model and analyze the grid with varying levels of DER penetration 2 Demonstrate and test varying levels of DER penetration in a distribution systems 3 Modify distribution system design approaches
System Impact Studies
4 Develop models to understand system impacts 5 Develop software to facilitate impact studies 6 Modify requirements for impact studies as appropriate
Microgrids
7 Model and analyze microgrids 8 Demonstrate and test microgrids 9 Develop design guidelines for microgrids
Wires Company Information Needs
10 Perform analysis of the information and data needs of wires companies 11 Develop and demonstrate systems for wires companies to monitor DER



Most of the past and current work in this area falls under pacing and emerging technologies in the research and development areas of the technology development pathway (Figure 4-6). These projects are mostly conducted or supported by government, non-profit or collaborative organizations.

Figure 4-6: Overall Activity Deploying Grid Impacts Strategies



Strategies
Modeling and Testing
1 Model and analyze the grid with varying levels of DER penetration 2 Demonstrate and test varying levels of DER penetration in a distribution systems 3 Modify distribution system design approaches
System Impact Studies
4 Develop models to understand system impacts 5 Develop software to facilitate impact studies 6 Modify requirements for impact studies as appropriate
Microgrids
7 Model and analyze microgrids 8 Demonstrate and test microgrids 9 Develop design guidelines for microgrids
Wires Company Information Needs
10 Perform analysis of the information and data needs of wires companies 11 Develop and demonstrate systems for wires companies to monitor DER

The following observations can be made regarding gaps in the four strategic thrusts:

- ***Modeling and testing* –** Private companies and EPRI have done work in the past in developing models and analyzing DER's impact on the electric power system. There is still a moderate gap in this area to evaluate these models for their applicability to DER. The next step in development where there is a significant gap is in the field demonstration and testing. The Distributed Utility Integration Testing Program at the Nevada Test site is a project that will pursue this strategy. However, it is still in the planning phase.

- ***System impact studies* –** There is a moderate gap in developing models to understand system impact and to develop software that will facilitate impact studies.

- ***Microgrids* –** There has been a significant amount of work on modeling and analyzing microgrids through government supported efforts such as CERTS. The next step, where there is a significant gap, is to demonstrate and test microgrids. UCI and CERTS are poised to do this type of work.

- ***Wires company information needs* –** EPRI has completed the work to understand the information needs of utilities with DER in their systems. EPRI has developed a prototype system to be deployed in 2001 with follow on demonstrations in 2002. There is a moderate gap in demonstrating such a system.

Market Integration

There are market integration strategies throughout the technology development chain (Figure 4-7). These strategies involve more regulatory and policy development initiatives than the other two areas, interconnection and grid impacts. However, technology will play a major role in achieving any policy changes, particularly for strategies in the research, development and demonstration areas. Strategies in the commercial area represent the "low hanging fruit" that would increase the level of DER penetration in the short term. They involve changing rates, tariffs and market rules and require little technology development. Strategies in the demonstration area are more focused on bringing about seamless customer DG response to real-time electricity prices, and are much more reliant on technology than the identified commercial area strategies. Most of the technology necessary to deploy these strategies will be shortly commercial. The technical challenges arise in the integration of these technologies. Strategies in the research and development area could bring about a major shift in the industry and make DER a major electricity resource to California.

Most of the market integration strategies have pacing competitive impact. These strategies are not yet fully embodied in commercial products; however, they are likely to have a substantial impact on the bases of competition in the future. Technologies include communications, control, metering and software. There are some strategies in advanced control and optimization and creating a separate DER market that have an emerging competitive impact. Their ultimate impact on competition in the future could be substantial but this is far from certain. In the case of creating a separate DER market, the required changes in regulations and laws require a long lead-time.

Figure 4-7: Strategies Addressing Market Integration

Market Integration

Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

Strategies

Current Market

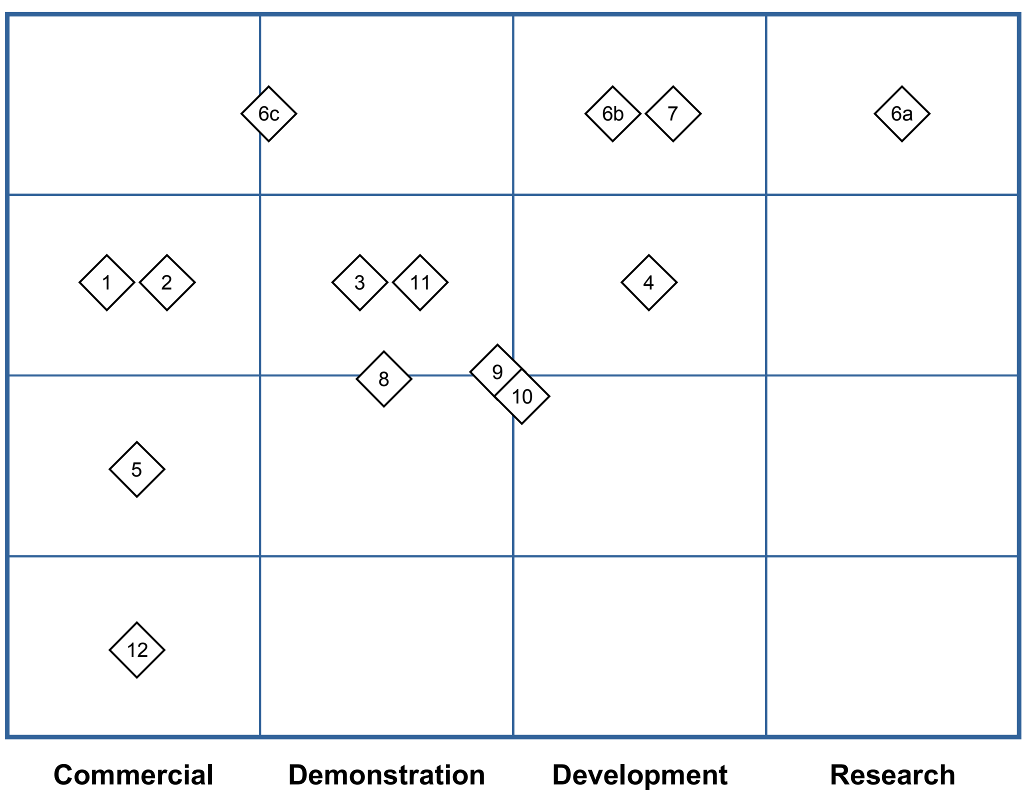
1 Assess current wholesale market rules for applicability to DER
2 Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
3 Reduce costs by creating critical mass through a demonstration program
4 Integrate the required technologies to reduce costs of participating in markets
5 Assess requirements for tariffs or rates

Advanced Market Concepts

6 Launch a new market for DER
  a Start from scratch, develop the best market structure for DER now and in the future
  b Assess the system requirements for communications, control, metering, software for billing and settlement
  c Pilot and then launch
7 Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)

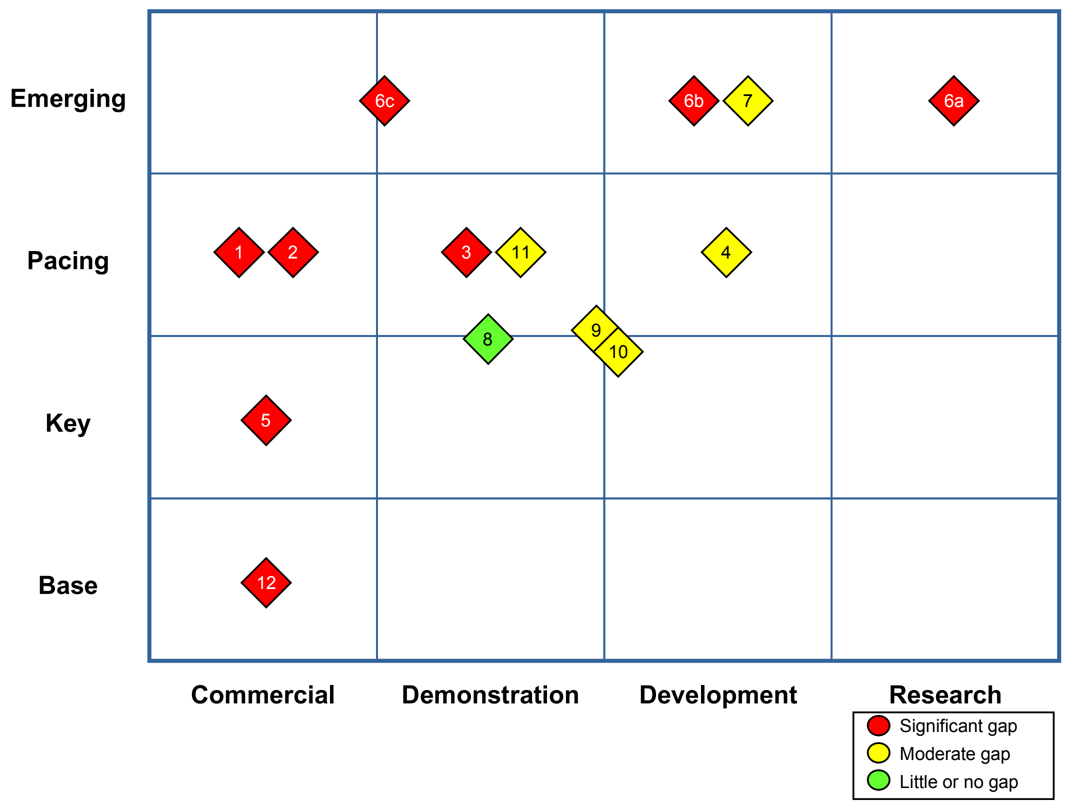
Enabling Technologies

8 Demonstrate aggregation and control of DER
9 Develop low cost metering
10 Develop low cost communications and control
11 Develop software to optimize DER in response to market price signals
12 Develop standards/protocols for communications/control



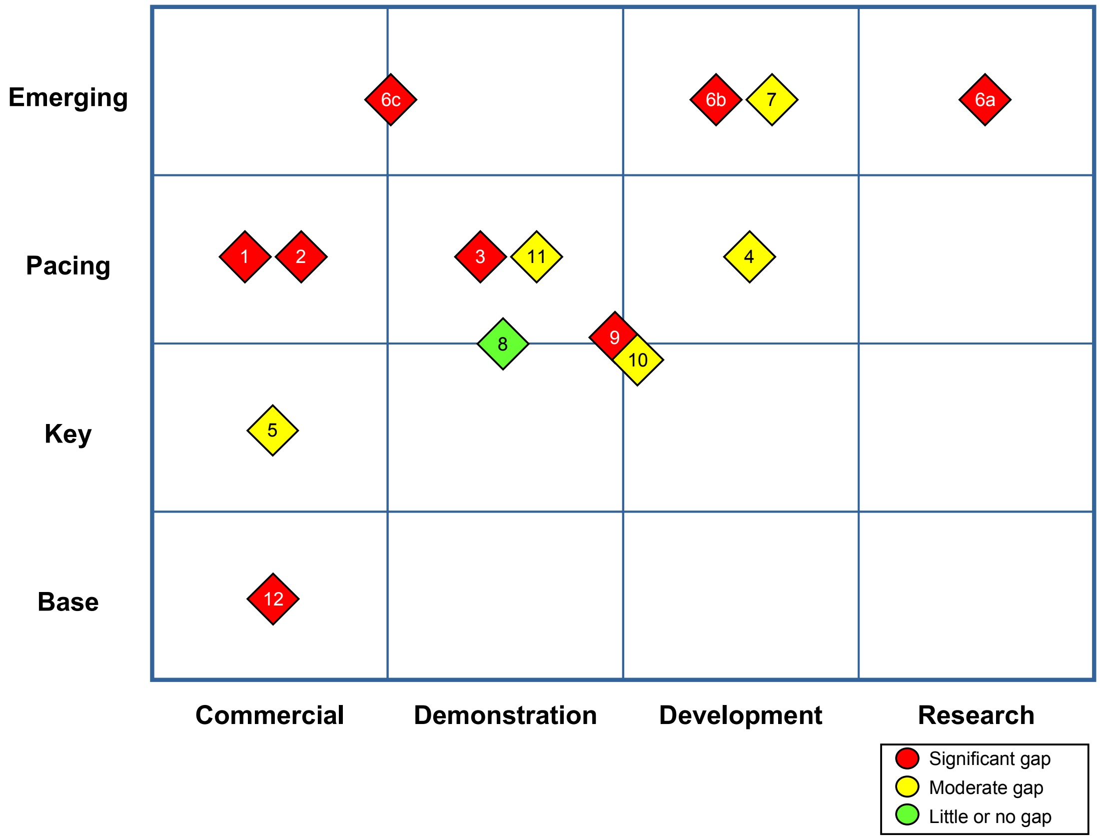
With the exceptions of low cost metering and assessing rates and tariffs, private sector and government/non-profit are working on the same strategies (Figures 4-8 and 4-9).

Figure 4-8: Private Activity Deploying Market Integration Strategies



Strategies
Current Market
1 Assess current wholesale market rules for applicability to DER 2 Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER 3 Reduce costs by creating critical mass through a demonstration program 4 Integrate the required technologies to reduce costs of participating in markets 5 Assess requirements for tariffs or rates
Advanced Market Concepts
6 Launch a new market for DER a Start from scratch, develop the best market structure for DER now and in the future b Assess the system requirements for communications, control, metering, software for billing and settlement c Pilot and then launch 7 Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)
Enabling Technologies
8 Demonstrate aggregation and control of DER 9 Develop low cost metering 10 Develop low cost communications and control 11 Develop software to optimize DER in response to market price signals 12 Develop standards/protocols for communications/control

Figure 4-9: Public/Non-Profit Activity Deploying Market Integration Strategies



Strategies
Current Market
1 Assess current wholesale market rules for applicability to DER 2 Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER 3 Reduce costs by creating critical mass through a demonstration program 4 Integrate the required technologies to reduce costs of participating in markets 5 Assess requirements for tariffs or rates
Advanced Market Concepts
6 Launch a new market for DER a Start from scratch, develop the best market structure for DER now and in the future b Assess the system requirements for communications, control, metering, software for billing and settlement c Pilot and then launch 7 Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)
Enabling Technologies
8 Demonstrate aggregation and control of DER 9 Develop low cost metering 10 Develop low cost communications and control 11 Develop software to optimize DER in response to market price signals 12 Develop standards/protocols for communications/control

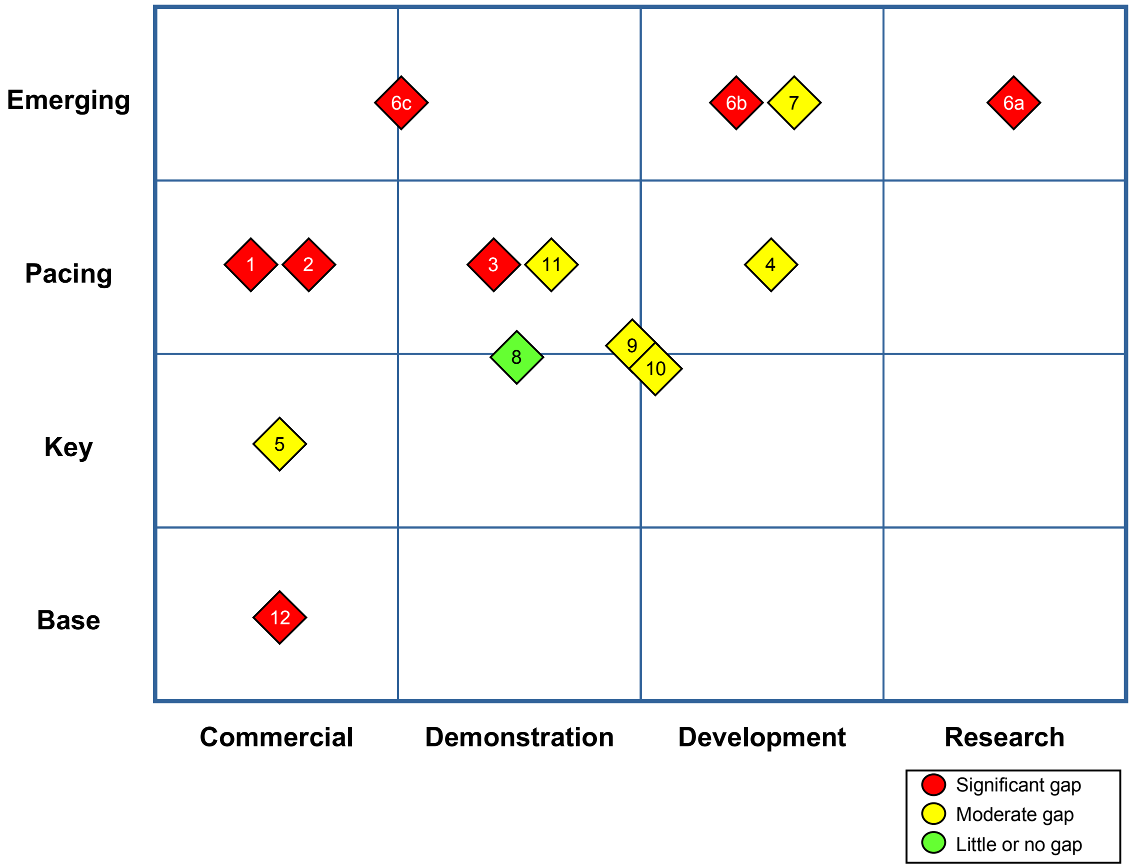
Combining the private and public sector activities, gaps can be identified (Figure 4-10) The following observations can be made regarding gaps in the three strategic thrusts in market integration:

- ***Current market*** **–** Most of the strategies in this area fall in the pacing category, having the potential to change the entire basis of competition in this industry. There are significant gaps in many of these strategies, particularly those that involve changing rates, tariffs and market rules without requiring significant technology development.

- ***Advanced market concepts*** **–** Strategies in this thrust are in the research and development stages, and are emerging technologies that could bring about a major shift in the industry and make DER a major electricity resource for California. Although there has been some technology development, a significant gap remains.

- ***Enabling technologies*** **–** Most enabling technology strategies have key/pacing competitive impacts. They are not yet fully embodied in commercial products, yet they are likely to have a substantial impact on the bases of competition in the future. Enabling technologies include communications, control, metering and software. Overall, there is a moderate gap in this thrust. While there has been a significant amount of activity to aggregate and control DER, moderate gaps remain in developing low cost metering, low cost communications and control, and optimization software. There is also a significant gap in developing standards and protocols for communications and control.

Figure 4-10: Overall Activity Deploying Market Integration Strategies

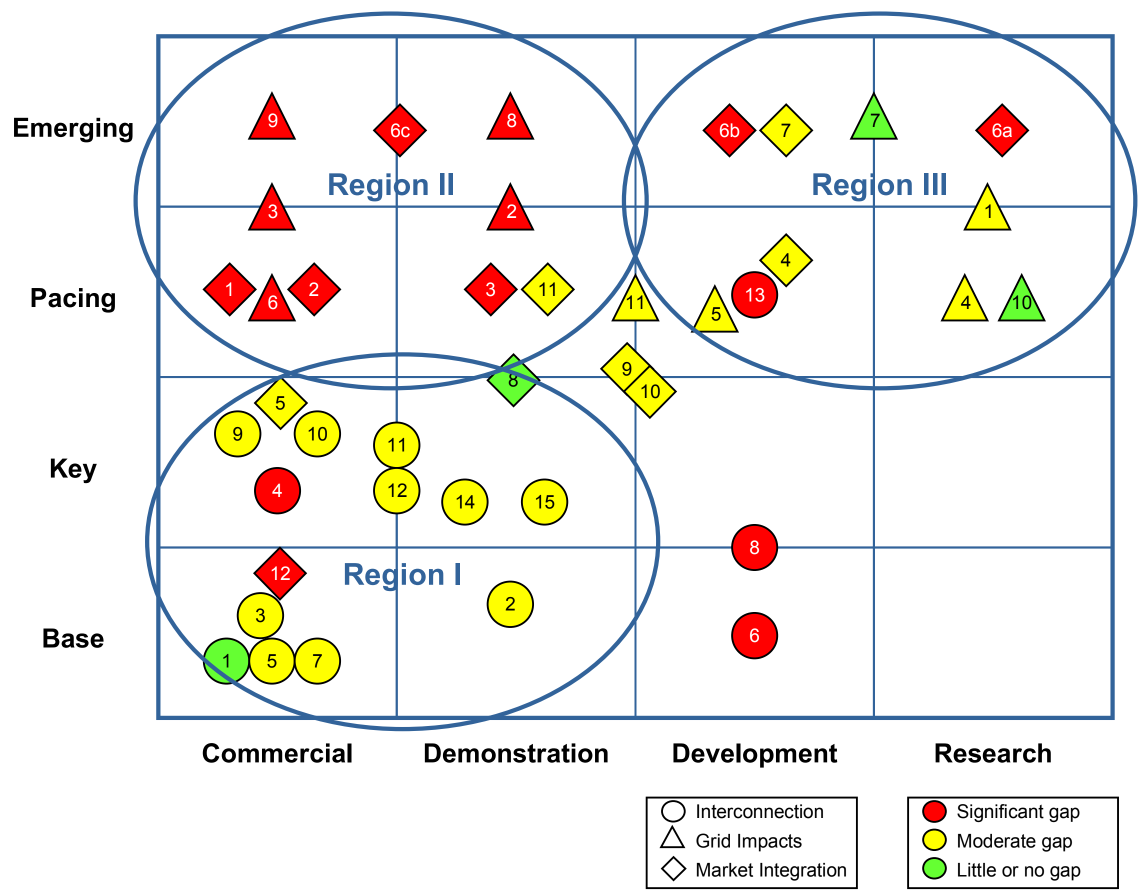


Strategies
Current Market
1 Assess current wholesale market rules for applicability to DER 2 Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER 3 Reduce costs by creating critical mass through a demonstration program 4 Integrate the required technologies to reduce costs of participating in markets 5 Assess requirements for tariffs or rates
Advanced Market Concepts
6 Launch a new market for DER a Start from scratch, develop the best market structure for DER now and in the future b Assess the system requirements for communications, control, metering, software for billing and settlement c Pilot and then launch 7 Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)
Enabling Technologies
8 Demonstrate aggregation and control of DER 9 Develop low cost metering 10 Develop low cost communications and control 11 Develop software to optimize DER in response to market price signals 12 Develop standards/protocols for communications/control

Setting Priorities

One approach to setting priorities is to examine where these strategies fall on the technology development chain and its competitive impact area. The first priorities should fall within base/key strategies with little or moderate activity that are in the demonstration or commercial stage of technology (Figure 4-11, Region I) as these strategies are likely to have the greatest impact on DER in the short-term. Emerging/pacing strategies in the commercial/demonstration stages would be the next area to look for priorities (Figure 4-11, Region II). However, some of these strategies would require development of emerging/pacing strategies in the research/development stages (Figure 4-11, Region III). This is one approach at setting priorities; a more robust examination of priorities will take place during the August 28, 2001 workshop.

Figure 4-11: Setting Priorities



Chapter 5: Preliminary Observations

Below are some preliminary observations drawn from the information gathered and analyzed thus far.

- The economic feasibility of many DER applications has yet to be demonstrated to a satisfactory degree on a wide-scale basis.

- The infrastructure to allow DER to participate in the marketplace and maximize its benefits to customers and the electric power system is still far from developed, thereby limiting the potential economic upside for end users.

- There are as many opportunities on the regulatory and policy side as there are on the technology development side. Indeed, in many instances, policy development has not kept pace with the development of technology.

- Stakeholders at all levels need to be engaged and educated to allow for follow-through to take place unhindered once the groundwork technology or policies are in place.

- Technology and policy development has already taken place over the past several years funded and supported by government and collaborative organizations. In recent years, commercial interest in this area has increased dramatically.

- Some significant opportunities still exist for high-impact projects in all three of the topic areas: interconnection, grid impacts and market integration.

  Interconnection - There are three strategic thrusts that could allow for a substantial amount of DER to be interconnected in radial and networked systems:

  - ***Standardization and adoption of new requirements and processes*** – Strategies in this thrust are focused on base technologies, as there will be little competitive advantage to be gained by any one company with the development and adoption of new standards. There has been a significant amount of activity in California and on a national level in developing standards in the past and going forward, leaving virtually no gap. There are, however, moderate gaps in the strategies that will adopt and refine these standards. Significant gaps exist in type testing and certification. There are also significant gaps in modifying these new requirements and developing standardized products for small DER; however it may be premature to pursue these strategies at this time.

  - ***Cost reduction and product improvement*** – Most of the strategies in cost reduction and product improvement are focused on key technologies that are likely to yield competitive advantage for the companies engaged in these activities. There are some companies and government funded activities in this area, but moderate gaps still exist. There is a significant gap in pursuing truly breakthrough technologies that could lead to substantial cost reductions. It is not clear if these breakthrough opportunities exist, but a preliminary study may be warranted.

- ***Compatibility*** – Strategies in compatibility are being pursued exclusively by EPRI PEAC. These activities are just getting underway and additional work is probably required to ensure the success of these strategies.

Grid Impacts – Most of the work involving grid impacts is funded or supported by government and/or collaborative research. Much of this work is still in the research phase. Over time, development and demonstration activities will become necessary. This work is considered either emerging or pacing since the competitive impact of these strategies is still unclear. There are four major thrusts that would lead to an understanding of what impact a high penetration of DER would have on the electric power system:

- ***Modeling and testing* –** Private companies and EPRI have done work in the past in developing models and analyzing DER's impact on the electric power system. There is still a moderate gap in this area to evaluate these models for their applicability to DER. The next step in development where there is a significant gap is in the field demonstration and testing. The Distributed Utility Integration Testing Program at the Nevada Test site is a project that will pursue this strategy. However, it is still in the planning phase.

- ***System impact studies* –** There is a moderate gap in developing models to understand system impact and to develop software that will facilitate impact studies.

- ***Microgrids* –** There has been a significant amount of work on modeling and analyzing microgrids through government supported efforts such as CERTS. The next step, where there is a significant gap, is to demonstrate and test microgrids. UCI and CERTS are poised to do this type of work.

- ***Wires company information needs* –** EPRI has completed an analysis of information needs and has developed a prototype system. There is a moderate gap in demonstrating such a system.

Market Integration – Strategies in this area involve more regulatory and policy development initiatives than those of the interconnection and grid impacts areas. However, technology will play a major role in achieving any policy changes. There are three strategic thrusts that may provide DER with access to robust markets and/or exposure to price signals that will maximize the benefits of DER to customers and the power system:

- ***Current market* –** Most of the strategies in this area fall in the pacing category, having the potential to change the entire basis of competition in this industry. There are significant gaps in many of these strategies, particularly those that involve changing rates, tariffs and market rules without requiring significant technology development.

- ***Advanced market concepts* –** Strategies in this thrust are in the research and development stages, and are emerging technologies that could bring about a major shift in the industry and make DER a major electricity resource for California. Although there has been some technology development, a significant gap remains.

- ***Enabling technologies* –** Most enabling technology strategies have key/pacing competitive impacts. They are not yet fully embodied in commercial products, yet they are likely to have a substantial impact on the bases of competition in the future. Enabling technologies include communications, control, metering and software. Overall, there is a moderate gap in this thrust. While there has been a significant amount of activity to aggregate and control DER, moderate gaps remain in developing low cost metering, low cost communications and control, and optimization software. There is also a significant gap in developing standards and protocols for communications and control.

More complete conclusions will be drafted following the workshop on August 28, 2001.

Appendix

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
ABB	Jaime Trevino; Tim La Berteaux	Trevino: Electric Systems Technology Inst.; La Berteaux: Distributed Generation Manager ABB Power T&D Company		1021 Main Campus Dr. Raleigh, NC 27606	Trevino: 919-856-3851 La Berteaux: 919-856-2330	Large supplier of an array of DG equipment ranging from basic interconnect components to technology that allows for the connection and control of a range of power units to the grid at a single point, incorporating a web server and IT.
AeroVironment				1610 s. Magnolia Dr. Monrovia, CA 91016	Tel: 626-357-9983 Fax: 626-359-9628	Produces control systems such as iPower which combines electronic power conversion with intelligent control systems.
Alpha Power Systems	Dana Sears	Vice President-Engineering and Sales	alphapower@earthlink.net	8626 Xyllon Court North, Suite 101 Minneapolis, MN 55445	763-315-1899	Paralleling switchgear, engine controls, remote monitoring and control of multiple sites from a single remote location. DG product - Dispersed Generation Paralleling Switchgear-(DGPS)
Alternative Energy Systems Consulting, Inc. (AESC)	Gerald L. Gibson; Ronald Ishii	Vice Presidents (both)		Gibson: 4715 Viewridge Avenue, Suite 200, San Diego, CA 92123; Ishii: 1945 Camino Vida Roble, Suite A, Carlsbad, CA 92008	Gibson: 858-560-7182; Ishii: 760-931-0517	AESC is active in intelligent software agents and is working with Reticular Systems to identify utility industry applications.
American Wind Energy Association (AWEA)	Jim Caldwell	Policy Director	jcaldwell@awea.org	122 C Street, NW, Suite 380 Washington, DC 20001	General line: 202-383-2500	Involved in various efforts using wind technology, primarily small wind and distributed wind.
Apogee Interactive	Joel Gilbert	CEO		2100 East Exchange Place Tucker, Georgia 30084	770-270-6504	Apogee produces peak load management software (The Demand Exchange), ebusiness solutions and business simulation software.
ASCO (Automatic Switch Co.)	George L. Williams	Marketing Manager Western Region Distributed Power	gwilliams@asco.com	2291 W. March Lane, Suite A200, Stockton, CA 95207	Tel: 209-472-7186 ext. 217; Fax: 209-472-1389	ASCO manufactures power control system, communication and transfer switches for critical power, peak shaving, utility interconnection.
California Independent System Operator (Cal ISO)	John Counsil; Dave Hawkin	Counsil: Senior Contract Analyst/ Engineer; Hawkin: Operations	jcounsil@caiso.com, dave.hawkins@gov.ca.gov	151 Blue Ravine Road, Folsom, CA 95630	Counsil: Tel: 916-608-5921; Fax: 916-351-2487	The ISO has received proposals from some entities that desire to implement and evaluate DER on a pilot project basis.
Cannon Technologies	Joe Cannon	Vice President	joel@cannontech.com	1212 East Wayzata Blvd. Wayzata, MN 55391	800-827-7966	Offers control and metering technology applicable to distributed generation.
Capstone Turbine Corp.	Joel Wacknov	Vice President-Power Electronics	jwacknov@capstoneturbine.com	21211 Nordhoff St. Chatsworth, CA 91311	Tel: 818-734-5549; Fax: 818-734-5382	Manufacturer of microturbines and related control technology
Celerity	Brad Hodges	V.P. and Project Manager	bhodges@celerityenergy.com		505-797-3408	Network Distributed Resource (NDR) Proprietary technology which provides synchronization, control, protection and power monitoring for DG

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
CERTS-Lawrence Berkeley Laboratory	Joe Eto; Chris Marnay		jheto@lbl.gov, c_marnay@lbl.gov	Lawrence Berkeley National Laboratory 1 Cyclotron Road, MS 90-4000 Berkeley, CA 94720	Tel: Eto 510-486-7284, Marnay 510-486-7028; Fax: 510-486-6996	The LBL maily focuses on the customer adoption of microgrids. Current research is focused on modeling more complex integrated microgrid scenarios and determining locations for the field testing of microgrids.
CERTS-non-LBL	Robert Lasseter; Robert Yinger; Abbas Akhil; Jeff Dagle; Sachis Meliopolos	Lasseter: Univ. Wisconsin, Yinger: SoCal Edison, Akhil: Sandia National Labs, Dagle: Pacific NW Lab, Meliopolos: Georgia Tech			Lasseter: 608-262-0186,Yinger: 626-302-8208, Akhil: 505-844-7308, Dagle: 509.375.3629, Meliopolos	CERTS organizes its research activities under four major areas to improve reliability, power quality, and other power needs. One major focus is the development of the microgrid. - Reliability Technologies and Issues for the energy grid of the 21st century to meet reliability needs in the restructured electricity industry - Real Time System Control to improve reliability of the interconnected T/D grid - Interconnection and Integration of Distributed Energy Resources - Reliability and Markets
Cummins Onan	Dan Erickson	Product Manager, Networks and Switchgear		1400 73rd Avenue NE Minneapolis, MN 55432	763-574-5228	Large manufacturer of power generation equipment
Distributed Power Services, Inc.	Kon McQuiston	President		2111 Business Center Drive Suite 100 Irvine, CA 92612	949-428-2560	Software
Distributed Utility Associates	Joseph Iannucci	Principal	dua@ix.netcom.com	1062 Concannon Blvd. Livermore, CA 94550	Tel: 925-447-0624; Fax: 925-447-0601	Presented work on the Distributed Utility Integration Test at the DOE Distributed Power Program Review at beginning of the year.
DTE Energy Technologies	Ronald Fryzel; Mark Fallek; Murray Davis	Fryzel: Manager-Market Development; Fallek: Chief Marketing Officer	Fryzel: fryzelr@dteenergy.com; Fallek: fallekm@dteenergy.com	37849 Interchange Drive Suite 100 Farmington Hills, MI 48335	Tel: Fryzel 248-427-2241; Fallek 248-427-2233, Fax: 248-427-2265; Davis: Tel: 248-427-2221, Fax: 248-427-2295	Energy monitoring, microgrid systems, application engineering and studies, DG technology sales
Eaton Corporation (Cutler Hammer)	John Wafer	Director of Technology-Electrical Distribution Products	johnawafer@eaton.com	170 Industry Dr. RIDC Park West Pittsburgh, PA 15275	Tel: 412-787-6520; Fax: 412-494-3417	Automatic transfer switches, power control panels
Electrotek Concepts	Howard Feibus, Jeff Smith	Feibus: Vice President	howardf@electrotek.com	Feibus: One Colonial Place 2111 Wilson Blvd. Suite 323 Arlington, VA 22201; Smith: 408 N. Cedar Bluff Rd Suite 500, Knoxville, TN 37923-3641	Feibus: 703-351-4492 ext. 124; Smith: 865 470-9222	Involved in a project with NYSERDA in the Aggregated Distributed Generators project. Active in research, consulting, software related to power quality and monitoring of electrical systems.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
ENCORP	Scott Castelaz	Vice President-Marketing and Strategic Planning	castelaz@rcnchicago.com	1512 S. Prairie Ave. Unit F Chicago, IL 60665	312-945-3036	Offering paralleling switchgear and energy automation software
Endecon Engineering	Chuck Whitaker				925-552-1330	Offers technical expertise and is supporting several projects in DER
Enercon Engineering	Larry Tangel	Vice President and General Manager	ltangel@enercon-eng.com	1 Altorfer Lane, East Peoria, IL 61611	309-694-1418	Enercon provides switchgear and parallel link controls for reciprocating engine gensets and turbines
Enermetrix	Jeff DeWeese	Co-Founder		3 Clock Tower Place, Maynard, MA 01754	978-461-0505	Transaction network/exchange and software
Engage Networks	Greg Andrews	National Account Executive		316 North Milwaukee St, Suite 410, Milwaukee, WI 53202	414-273-7600	Develops energy management techniques through SCADA and IP interface cards (web-enabling of GE meters)
EPRIsolutions	Dan Rastler			EPRI: 3412 Hillview Ave., Palo Alto, CA 94304	650-855-2521	
Gas Technology Institute (GTI)	Ted Bronson; William Liss	Bronson: Associate Director-Distributed Energy; Liss:	ted.bronson@gastechnology.org	1700 South Mount Prospect Road Des Plaines, 60018-1804	Tel: 847-768-0637, Fax: 847-768-0501; Liss: 847-768-0753	Industry backed nonprofit organization involved that has been active in distributed generation issues with several relevant projects underway.
GE Corporate R&D	Dr. Richard Zhang	Project Leader and Electrical Engineer	zhangr@crd.ge.com	Building K1, Room 2C33 Niskayuna, NY 12309	Tel: 518-387-5313; Fax: 518-387-7592	The research arm of General Electric is active in DER technology development and is leading a DOE cofunded project called "Predictive Modeling, Grid Interconnection Issues, Communications".
GE Distributed Power	Paul McGuire; Wayne Elmore	Senior Business Manager-GE Distributed Power (both)	McGuire: paul.mcguire@ps.ge.com; Elmore: wayne.elmore@ps.ge.com	McGuire: 3633 E. Inland Empire Blvd., Suite 800 Ontario, CA 91764; Elmore: 20 Technology Park Suite 300 Norcross, GA 30092	McGuire: Tel: 909-477-5789, Fax: 909-477-5748; Elmore: Tel: 770-662-7024, Fax: 770-447-7793	Large manufacturer of power generation equipment.
GE Industrial Systems	Daniel Klenke; Tom Mc Gibbon	Klenke: Manager, Ener.ge Program; McGibbon: Business Development Manager	daniel.klenke@indsys.ge.com; patrick.mcgibbon@indsys.ge.com	Klenke: 12101 Woodcrest Executive Drive St.Louis, MO 63141; McGibbon: 350 Humboldt Dr. North Henderson NV 89014	Klenke: Tel: 314-579-7025, Fax 314-579-7070; McGibbon: Tel: 702-433-6396, Fax: 702-433-6396	Produced control and protection equipment.
GE Zenith Controls	David Leslie		david.leslie@indsys.ge.com	GE Zenith Controls 1 Oak Hill Center, Westmont, IL 60559	773-299-6928	GE Zenith Control manufactures transfer switches, paralleling switchgear, and communications systems.
Generac	Eric Neitzke	Engineering Inquiries; VP of Sales & Marketing	eneitzke@generac.com	P.O. box 8 Waukesha, WI 53187	262-544-4811 ext. 2777	Develops transfer switches, paralleling switchgear, and GenLink software program for remote monitoring control panels.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
Honeywell Sensing and Control	Louis Warren	Electrical Engineer		Honeywell Power Systems Albuquerque, NM	505-798-6031	Developed embedded sensors and controllers, ATRIUM an Internet-based service that can monitor and integrate equipment, operations, and energy information from multiple sites.
Illinois Institute of Technology-Grainger Power Lab	Dr. Alexander J. Flueck			3301 South Dearborn Street Electrical and Computer Engineering Department Illinois Institute of Technology Chicago, IL 60616-3793 USA	Phone: 312-567-3625 Fax: 312-567-8976	Focuses on congestion management research with transmission of power.
Intellution (Emerson Electric)	Rob Davidson; Greg Maciel; Lillian Allen	Davidson: Inside Sales Allen and Maciel: Part of **BM2Solutions**		325 Foxborough Blvd. Foxborough, MA 02035	General Number: 508-698-3322; Davidson: 800.526.3486 x7607; Maciel: 949.364.9090x 11; Allen: 949.364.9090x 16	
Invensys Controls				Carlisle Place, London SW1P 1BX	44 (0) 20 7834 3848	Invensys is developing an Internet-based energy management and monitoring solution, and plans to integrate Capstone MicroTurbine generation into its demand side management solutions
Itron	Dennis A. Shepherd	VP and General Manager, Energy Information Systems			919-876-2600	Advanced metering
Johnson Controls				3655 Northpoint Parkway Suite 200 Alpharetta, GA 30005	678-297-4100	Facility Management and Building Control Systems
Kelso Starrs and Associates	Tom Starrs	Principal	kelstar@nwrain.com	14502 SW Reddings Beach Road, Vashon WA 98070	Tel: 206-463-7571; Fax: 206-463-7572	Conducting a survey to interview a representative sample of DG facility developers and owners to determine interconnection problems and obstacles.
Kinectrics (formerly Ontario Power Technologies)	Blake Morrison	Director of Business Development	Blake.Morrison@kinectrics.com		954-659-9282	Third party company that provides consulting services through science and engineering to the energy markets. They conduct equipment testing and demonstrations on products such as fuel cells and microturbines.
Kohler Power Systems	Mark Siira	Director of Business Development-Generation Division	siiramar@kohlerco.com	444 Highland Drive, MS 072, Kohler, WI 53044-1541	920-803-4949	Manufacturer of generation equipment.
Los Angeles Department of Water and Power (LA DWP)	Bill Glauz	Manager of Distributed Generation	wglauz@ladwp.com	111 N. Hope St. Room 1004, Los Angeles, CA 90012	Tel: 213-367-0410; Fax: 213-367-0777	Municipal utility serving the city of Los Angeles

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
MIT Energy Laboratory	Marija D. Ilic; Stephen R. Connors ; J. Cardell, R. Tabors, Jefferson Tester	Illic: Principal Investigator; Connors: Support Investigator	Illic: ilic@mit.edu; Connors: connorsr@mit.edu; Tester: testerel@mit.edu		Ilic: 617-253-4682, Connors: 617-253-7985	The energy laboratory does a variety of work regarding distributed generation including predictive modeling, cost reduction, price and regulatory analysis, and quality of service.
National Renewable Energy Laboratory (NREL)	Richard DeBlasio	Technology Manager- Distributed Power Programs	deblasid@tcplink.nrel.gov	1617 Cole Blvd. Golden, CO 80401	Tel: 303-275-4333; Fax: 303-275-3835	The DOE distributed power program supports numerous technology development and demonstration projects in distributed power; It is also actively supporting the formulation of new standards.
National Rural Electric Cooperative Association (NRECA)	Edward Torrero	Senior Program Manager- Cooperative Research Network	ed.torrero@nreca.org	4301 Wilson Blvd. SS9-204 Arlington, VA 22203	Tel: 703-907-5624; Fax: 703-907-5518	Evaluation of the field performance of fuel cells and microturbines to better understand potential benefits and barriers
NEISO	N/A					Also pursuing methods to reduce load during peak capacity; also has two classes of interruptible loads: Class 1 (following a Contingency Loss) and class 2 (price-responsive, notification sent when forecasted that the ECP will exceed $100/MWhr)
NiSource Energy Technologies	Pete Disser	Vice President of Strategy	ptdisser@nisource.com	801 E. 86th Ave. Merrillville, IN 46410	Tel: 219-647-6070; Fax: 801-749-1605	Leading the DOE cofunded project "System Integration of Distributed Power for Complete Building Systems"
North Carolina Solar Center	Shawn Fitzpatrick		safitzpa@eos.ncsu.edu	N.C. Solar Center, Campus Box 7401, NCSU, Raleigh, NC 27695	Tel: 919-515-7147	Developed a "Guide to PV Interconnection Issues" along with Interstate Renewable Energy Council (IREC); Endecon Engineering, Kelso Starrs & Associates
Northern Power Systems	Lawrence Mott; Chach Curtis	Mott: Director- Special Projects	ccurtis@northernpower.com	182 Mad River Park One North Wind Road P.O. Box 999 Waitsfield, VT 05673-0999	General line: 802-496-2955	Engine Control System (ECS) is a line of generator set controls and switchgear. RemoteViewTM software allows remote monitoring and control of power systems.
NYISO, NYSERDA, Competitive ESCOs	N/A					Load reduction programs
Oak Ridge National Laboratory	Mike Karnitz					Coordinating numerous projects involving industrial DG.
Omnimetrix	Kent Heuser		akheuser@omnimetrix.net	Atlanta, GA	770-209-0012	Remote monitoring and notification of emergency generator conditions to cell phone, pager, etc.
Omnion (S&C Power Electronics Division)				2010 Energy Drive, East Troy, WI 53120	262-642-7200	Grid-parallel inverters
Orion Engineering Corporation	Dr. Thomas Regan; Herb Sinnock			Herb Sinnock, 40 Marion Street, Sommerville, MA 02143	Herb Sinnock, 617.625.3953 Tom Regan, 978.337.1352	Beginning a three-year development effort to produce a household generation controller and demonstrate the ability of a group of controllers to operate through a neural network to provide a smart, technologically sophisticated, but simple, efficient and economic solution for aggregating a community of small distributed generators into a virtual single large generator capable of selling power internally or externally to a utility, ISO or other entity, in a coordinated manner.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
Overdomain, LLC	Crisman Cooley	Managing Member	ccooley@overdomain.com	599 Via El Cuadro Santa Barbara, CA 93111	Tel: 805.683.0938; Fax: 253.276.3206	Distributed Energy Neural Network Integration System (DENNIS)
Pacific Gas & Electric	Sun Chase; Jeff Goh				Chase: 415-973-2223; Goh: 415-973-0260	Major investor owned utility serving northern California.
PJM	N/A					Load Response Program - In order to reduce demands on Load-Serving Entities, a limited number of participants are given two options: compensation for end use customers who help reduce load during an emergency or work through the market participants to reduce load, who will then share the savings with the end-users (economic).
Power Measurement				2195 Keating Cross Rd., Saanichton, BC Canada V8M 2A5	1-250-652-7100	Performance MeteringTM Solutions -ION® web-ready software and intelligent electronic meters, software and communications (including internet)
Power Technologies Inc.	P.P. Barker	Senior Consultant		1482 Erie Blvd, P.O. Box 1058, Schenectady, NY 12301-1058		Provides power system simulation and modeling software as well as generation optimization software
PowerWeb Technologies	Lothar Budike	President and CEO				Omni-link® Internet Energy Platform - Multifunctional, internet-based enterprise energy information software
Public Utility Commission of Texas	Ed Ethridge	Electrical Production Engineer	ed.ethridge@puc.state.tx.us	1701 N. Congress Ave. PO Box 13326 Austin, TX 78711-3326	Tel: 512-936-7340; Fax: 512-936-7361	The state of Texas has established rules and technical standards for DER interconnection .
RealEnergy	Steven Greenberg		sgreenberg@realenergy.com	300 Capitol Mall, Ste 120, Sacramento, CA 95814	916-325-2500 x108	Independent power producer with equipment operating at site of power consumption
Reflective Energies	Edan Prabhu		edanprabhu@home.com		Tel: 949-380-4899	Reflective Energies is assisting with Focus I
Regulatory Assistance Project	Cheryl Harrington		rapmaine@rapmaine.org			RAP is involved in a DOE cofunded project identifying regulatory options for DER.
Resource Dynamics Corporation	Richard Friedman	Chairman	nrf@rdcnet.com	8605 Westwood Center Drive, Ste. 410 Vienna, VA 22182	703-356-1300 x203; Fax: 703-356-2230	IEEE/P1547 - Electric Power Resources Interconnected with the Electric Power System
Retx.com				Plaza 400, Suite 180, 5883 Glenridge Dr, Atlanta, GA 30328-5339	888-228-RETX	This company offers online hosting and software for retail choice programs including transaction support, metering and settlement, and analysis.
Sacramento Municipal Utility District (SMUD)	Chris Trinidad	Principal Distribution System Engineer	ctrinid@smud.com	6001 S Street MS# D104 Sacramento, CA 95817-1899	Tel: 916-732-6969; Fax: 916-732-6556	SMUD is a municipal utility that has been active in PV technology.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
Sandia National Lab	Akhil Abbas and Jerry Ginn	Abbas: Principal Member; Ginn: Senior Member of Technical Staff	Abbas: aaakhil@sandia.gov; Ginn: jwginn@sandia.gov	P.O. Box 5800 - MS 0704 (Abbas)/MS 0753 (Ginn), Albuquerque, NM 87185	Abbas: 505-844-7308 and Ginn: 505-845-9117	Akhil Abbas was a speaker at the CADER Conference: Market Deployment-The Microgrid Concept
SatCon Technology Corporation	L.E. Lesster	General Manager-Technology Center	lesster@satc.com	161 First St, Cambridge, MA 02142	Tel: 617-349-0927; Fax: 617-661-3373	Developing power electronics equipment and energy storage technology.
Schneider Electric (Merlin Gerin, Modicon, SquareD, Telemecanique)	Jim Giordano		giordanj@squared.com	1415 Roselle Rd Palatine, IL 60067	615-287-3583	Manufactures control and protection equipment
Sempra Energy (San Diego Gas and Electric)	Mark Ward		mward@sempra.com		Mark Ward 619-696-4014, Vic Romero 858-650-4084, Tom Bilaek 858-654-8795, Mike Iammarino 858-650-6166	Major investor owned utility serving the greater San Diego area.
Siemens Westinghouse Power Corp	Allan Casanova	Director of Business Development & Admin.-Stationary Fuel Cells	allan.casanova@swpc.siemens.com	1310 Beulah Road Pittsburgh, PA 15235	Tel: 412-256-2813; Fax: 412-256-1310	DEMS economic dispatch tool (control and optimization of decentralized DG)
Silicon Energy	Afshin Afshari	Product Manager, Distributed Energy Management	aafshari@SiliconEnergy.com	1010 Atlantic Ave, Alameda, CA 94501	877-749-2600, 510-263-2672	Offers network/platform and software for reporting and analysis of energy usage and cost management...also includes bill auditing and analysis features.
Sixth Dimension, Inc.	Wade Troxell; Ph.D.	President & COO		1201 Oakridge Drive, Suite 300 Fort Collins, Colorado 80525	970-267-2021	Produces software for DER with products such as 6D iNET Network, 6D PowerPortal, 6D PowerPak and Embedded Site Server.
Southern California Edison	Gerome Torribio		torribgg@sce.com		626-302-9669	Major investor owned utility serving southern California
Stanford University Energy-Energy Modeling Forum	Hillard Huntington	Executive Director	hillh@stanford.edu	Terman Engineering Center, Room 406 Stanford, CA 94305-4026	Phone:650-723-0645 Fax: 650-725-5362	Involved in large level modelling; DG has been very difficult to analyze-not very active
Thomson Technology	Rick Martin	Vice President of Sales and Marketing	rmartin@thomsontechnology.com	9087A - 198th Street, Langley, BC V1M 3B1, Canada	Tel: 604-888-0110 ext. 305; Fax: 604-888-3381	Manufactures control panels and switchgear, transfer switches, remote monitoring and control software.
Underwriters Laboratories Inc.	Tim Zgonena	Sr. Project Engineer	Timothy.P.Zgonena@us.ul.com	333 Pfingsten Rd. Northbrook, IL 60062	Tel: 847-272-8800 ext. 43051; Fax: 847-509-6298	UL1741 - The Standard For Inverters, Converters and Controllers For Use In Independent Power Production Systems

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
University of California, Irvine	Kim Bergland		kb@nfcrc.uci.edu, jb@nfcrc.uci.edu	National Fuel Cell Research Center University of California, Irvine Engineering Laboratory Facility Irvine, California 92697-3550	Tel: 949-824-1999; Fax: 949-824-7423	Involved in several DER projects.
Urban Consortium Energy Task Force	Roger Duncan	Vice President of Austin Energy	roger.duncan@austinenergy.com			Active as a resource for DG information to large cities and municipal utilities.
Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC)	Dr. Giri Venkataraman an; Fernando Alvarado	Venkataraman an: Assistant Professor	giri@engr.wisc.edu; alvarado@engr.wisc.edu		Venkataraman an: 608.262.4479; Alvarado: 608-262-8900	Activities include inverter control technologies to increase reliability and reduce costs as well as DG pricing and locational models.
Woodward Industrial Controls	Paul Johnson	Marketing Manager	pajohn@woodward.com	PO Box 1525 Fort Collins, CO 80522	970-498-3562	EGCP-2 Control and synchronization of multiple units
Xantrex (Trace Engineering and Trace Technologies)	Ray Hudson	Vice President of Emerging Markets and Advanced Development	ray.hudson@xantrex.com	161 S. Vasco Rd, Suite G, Livermore, CA 94550	Tel: 925-245-5407; Fax: 925-245-1022	Grid-parallel inverters